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P C

AMIGA

S T

SHUTTLE™

INSTRUCTION

MANUAL

BACKGROUND

Developed by The National Aeronautics and Space Administration [NASA], the Space Shuttle is the world's first re-usable spacecraft designed to be launched in an upright position, transport cargo into near Earth Orbit [100 to 217 nautical miles] and return to Earth landing safely on a runway just like a conventional aircraft.

At launch, thrust is provided by the two Solid Rocket Boosters [SRBs] and the three Space Shuttle Main Engines [SSMEs]. After about two minutes, the SRBs separate from the External Tank [ET] and fall into the ocean to be recovered by specialist rescue teams. After about eight minutes [MECO] occurs and, moments afterwards, the ET is also separated, thereafter falling into the ocean. In addition to the main engines there are two Orbital Maneuvering System engines [OMS] which give the Orbiter the final "kick" into orbit. The OMS is used to instigate major maneuvers while in orbit and also to perform the "de-orbit burn" which slows the Shuttle for re-entry. There is also a complex Reaction Control System [RCS], used to control the pitch, yaw and roll of the vehicle outside the atmosphere. On re-entry, the RCS is phased out in favor of the conventional elevon and rudder controls, as the Orbiter glides down to a safe landing.

There are two main launch sites: The Kennedy Space Center in Florida and Vandenburg Air Force Base in California. There are landing sites at both of these launch sites, as well as at Edwards Air Force Base, California and White Sands, New Mexico. And, if the worst comes to the worst, there are emergency landing sites in numerous locations around the world, including Spain and Africa.

LOADING SPACE SHUTTLE - THE SIMULATOR

IBM Version

Insert Disk 1 into Drive A:

Type INSTALL then follow the prompts to copy the all the necessary files to the hard drive. Be sure to select the correct graphics mode, and sound supports during this procedure.

If you find difficulties while installing be sure that you have approximately 1.4 megabytes of free space on your hard drive and at least 530k of free base memory. If you are still having difficulties contact Virgin Games technical service and we will be happy to help get you up and running.

Amiga Version:

Please see the appropriate installation card for the Amiga version.

Atari ST Version:

Please see the appropriate installation card for the Atari ST version.

Using the Simulator

INTRODUCTION

(1) Quick Start

This section is intended to show you how to get into the product quickly so you can have a look around **SPACE SHUTTLE - THE SIMULATOR** without having to go through all the set-up procedures. This isn't intended to be a tutorial in any way and should be used as a first look at the product.

(2) Getting Started

This section is intended to familiarize you with the product and the many different control methods used to operate **SPACE SHUTTLE - THE SIMULATOR**. Due to the complexity of this product, we feel that it is essential that you read this section before getting into the game proper, certainly before attempting any of the main missions. After reading **Getting Started**, you should be able to find your way around without having to constantly refer to the manual or reference cards.

(3) Reference

In this section you'll find all the information necessary to gain an in-depth understanding of the operations of the Orbiter. It is intended to be used at those times when you feel confused or don't quite understand what Mission Control is asking you to do.

(4) Mission Procedures

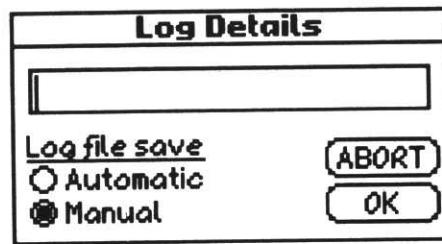
In this section you'll find a detailed breakdown of every major action the crew of the Orbiter is required to take during Launch, Orbit, Re-entry and Landing, giving times, heights, switches and so on. In **SPACE SHUTTLE - THE SIMULATOR**, not all of these procedures are followed; it is possible to fly the Orbiter on Manual using the Manual Launch, Manual Re-entry and Manual Landing procedures outlined in this section.

(5) Mission Profiles

In this section you'll find a detailed history of the Space Shuttle's missions, from the first test flight to the last, tragic flight of Challenger.

1. Quick Start Guide

1. Screens, Switches and Dials - User Interface



WINDOWS

To interface with any windows and/or boxes that appear during the game, for instance the Log Save window, simply move the pointer to the required part of the window and click the left button.

To change any data in these boxes, simply position your cursor in the relevant box, for instance the User Name box, and overwrite it. To move the cursor to a specific point in this box use the cursor keys, or, if you wish to erase the current information, use Backspace. However, holding the cursor keys or Backspace key down will not make the cursor move across the box - you have to press it repeatedly to do this.

MOUSE CONTROL

Once in the simulator, you can scroll around your chosen panels simply by moving the mouse: when the pointer comes to the edge of the screen, the screen will scroll in that direction.

To move the switches either up or down, or from left to right, click the left mouse button for up, or left, and the right mouse button for down, or move the mouse to the right. Where a switch has more than two settings, continue to click the button in the required direction.

Clicking the left and right mouse buttons simultaneously brings up the menu bar, while clicking them again removes it.

Finally, when in the PANEL OVERVIEW view, clicking the right mouse button scrolls you round the different views, while the left button selects the one you're currently on.

KEYBOARD CONTROL

To move around the screens, press E to scroll down, X to scroll up, S to scroll right and D to scroll left.

For those running **SPACE SHUTTLE - THE SIMULATOR** on a PC without a mouse, the above mouse controls can be emulated by the keyboard as follows: to operate the switches, use the Shift and Home keys together to simulate the left mouse button, and Shift and Pg Up for the right button. Using Shift together with the keypad cursor keys [2,4,6 & 8] emulates the pointer movement. Thus all mouse functions described above can be emulated by using these keys.

GAME RUNNING ICON

This appears whenever you're running the simulator, and denotes that it's in progress. Occasionally other symbols will flash inside this icon:

'/'	- Time running
'M'	- Message on teleprinter from ground control - press F7 to read
'S'	- Time Skip facility is in operation.
'T'	- Time Advance facility is in operation.

When you pause the game, whichever of these symbols is on the screen at the time will flash.

For full details of these facilities see their respective sections.

• 11 •

Keys with SHIFT held down.

Home	Left mouse button
Pg Up	Right mouse button
CUR UP	Move pointer up
CUR DOWN	Move pointer down
CUR LEFT	Move pointer left
CUR RIGHT	Move pointer right

Keys with ALT held down.

P	Toggle "Game running" icon ON/OFF
[]	Slow movement of RMS joint @ 0.2
CUR UP	-Z translate SHUTTLE
CUR DWN	+Z translate SHUTTLE
CUR LFT	-Y translate SHUTTLE
CUR RT	+Y translate SHUTTLE
+	+X translate SHUTTLE
-	-X translate SHUTTLE

Keys used on the numeric keypad.

+-	Scroll through display on Aft CRT
Home	Camera Roll left
End	Camera Roll right
Pg Up	Camera Pitch up
Pg Dn	Camera Pitch down
Ins	Camera Yaw left
Del	Camera Yaw right

CONTROL key sequences

Control	C	+	Y	Turn the cursor on
	C	+	N	Turn the cursor off
Control	F	+	Y	Turn sound on
	F	+	N	Turn sound off
Control	G	+	A	Arm landing gear
	G	+	D	Drop landing gear

Control	H	+	1	Full-on Auto
	H	+	2	First Simulation
	H	+	3	First Command
	H	+	4	Veteran
	H	+	5	Fully Manual
	H	+	0	Automatic selection
Control	J	+	1	Select Shoulder Yaw
	J	+	2	Select Shoulder Pitch
	J	+	3	Select Elbow Pitch
	J	+	4	Select Wrist Pitch
	J	+	5	Select Wrist Yaw
	J	+	6	Select Wrist Roll
Control	L	+	S	Save log file
Control	P	+	F	Goto Front panel
	P	+	A	Goto Aft panel
	P	+	C	Goto center panel
	P	+	L	Goto left panel
	P	+	R	Goto right panel
	P	+	O	Goto overhead panel
	P	+	M	Goto right-aft panel
	P	+	N	Goto lower-aft panel
	P	+	H	Slow down panel movement (use up to 3 times)
	P	+	J	Speed up panel movement
Control	Q	+	Y	Quit to main menu
	Q	+	N	Return to simulator
	Q	+	D	Return to DOS [not Amiga/ST]
Control	S	+	T	Start Time Skip
	S	+	P	Start Time Skip and pause when finished
	S	+	C	Turn off Comms.
Control	T	+	T	Time advance
	T	+	P	Time advance and pause
Control	W	+	T	Open Time Advance window
	W	+	S	Open Time Skip window
	W	+	D	Open Time Of Day window
	W	+	M	Open MET window
	W	+	C	Open Detail Complexity window
	W	+	G	Open Ground View window
	W	+	H	Open Help Level window
	W	+	L	Open Log Options window

FUNCTION keys.

No shift/ctrl/alt	SHIFT +	ALT +
f1 Last panel	Select Panel	
f2 Left HUD	Right HUD	
f3 Left window	Right Window	
f4 Left AFT	Right AFT	
f5 Left Payload Bay	Right Payload Bay	
f6 Inside MMU	Release MMU	Attach MMU
f7 Mission Control text	External Tank View	
f8 Ground View	Sel Ground View	Roaming MMU view
f9 CCTV View	Crawler View	747 View
f10 Roaming Camera	Left SRB Camera	Right SRB view

MMU KEYS

ROTATION

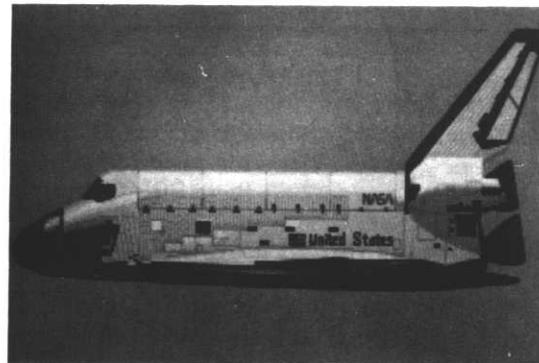
U	Pitch up
N	Pitch down
H	Roll left
J	Roll right
B	Yaw left
M	Yaw right

Translation

ALT +	U	-Z	Translate
ALT +	N	+Z	Translate
ALT +	H	-Y	Translate
ALT +	J	+Y	Translate
ALT +	B	-X	Translate
ALT +	M	+X	Translate

2. Getting Started

MAIN MENU



SPACE SHUTTLE - THE SIMULATOR is controlled by two menu systems, the **MAIN MENU**, for all applications prior to launch, and the **SIMULATOR MENU**, for all in-flight operations. For the latter, see later. Both menu bars appear at the top of the screen.

The **MAIN MENU** contains information that will be useful in familiarizing you with the Space Shuttle and its systems, and to help you choose the level of customizing you require, as well as Launch and Landing sites and the mission details.

1. ORBITER

This first menu option contains four further sub-options:

1. ABOUT SPACE SHUTTLE

- gives the publishing and development credits for **SPACE SHUTTLE - THE SIMULATOR**.

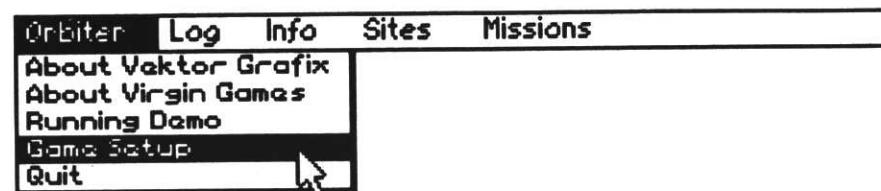
2. RUNNING DEMO

This takes you straight to the launch pad, where you're taken through a typical mission that demonstrates the many different functions and aspects of **SPACE SHUTTLE - THE SIMULATOR**. In this demo, you'll see the Orbiter launch into orbit and deploy a satellite. This demo lasts for approximately fifteen minutes and allows you just to sit back and watch.

To access this demo, first load up the game as detailed above. To bypass the loading screen, click the left mouse button [or SPACE BAR]. Next, select **RUNNING DEMO** from the **ORBITER** menu at the opening screen and sit back and watch the Shuttle launch and deploy its satellite.

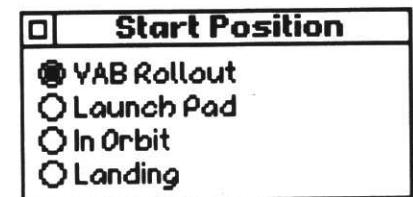
To quit the demo, press ESC to access the SIMULATOR MENU, select MISC, and then QUIT TO MAIN MENU. This will take you back to the MAIN MENU.

3. GAME SET UP



This feature allows you to customize the various aspects of the game. This has six further options within it, which appear in a window called 'SELECT WINDOW' whenever you select 'GAME SET UP'. From here, by selecting with the mouse and then clicking on the OPEN icon, you go to the following:

START POSITION

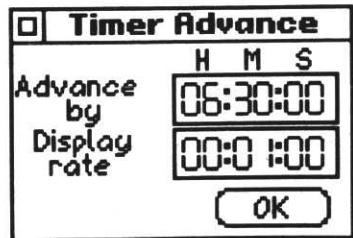


This feature brings up another window that allows you to start either from VAB [VEHICLE ASSEMBLY BUILDING] ROLLOUT, i.e., right from the beginning, LAUNCH PAD, IN-ORBIT or LANDING. You click on the required button, then remove this second window by clicking on the box in the top left hand corner.

TIMER ADVANCE

Clicking on TIMER ADVANCE first brings another window onto the screen, in which are two options:

ADVANCE BY - This feature allows you to move to any point in the simulator you want: just type in the required time. When the simulator is started, you'll see a



letter 'T' in the GAME RUNNING ICON that denotes that the simulator is now in TIME ADVANCE mode. While in this mode, the simulator pauses until it finds the required point. When it has done so, the letter 'T' will disappear, and you'll be returned to normal real time. The time advance will stop, however, if a message comes up for an in-flight operation to be carried out [unless the help level is set to completely automatic of course - see HELP LEVEL, below.]

DISPLAY RATE - This feature allows you to customize the rate at which the view is updated. For instance, if you type in **10 MINUTES**, then every new frame you'll see will be points ten minutes apart. Of course, these views wouldn't change at this speed in real time, only within the simulator.

TIME SKIP SET

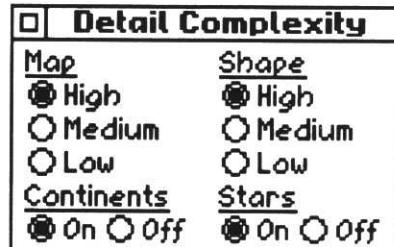


This differs from TIMER ADVANCE, above, only in that it simply allows you to jump to a designated point in the mission. Selecting this option brings up another window, in which a box marked 'ADVANCE TO' appears, set out in hours, minutes and seconds. Below this are two icons marked 'T+' , meaning time after lift off, and 'T-' , meaning time before lift off.

To reach a set point in time within the mission, simply select 'T-' or 'T+' and type in the required time. The simulator will then time advance until it has reached this point, skipping through time at a rate of approximately one minute of simulator time to one second of real time.

DETAIL COMPLEXITY

This feature allows you to set the map and/or the shape complexities. In each case, a choice of levels is offered. The choice of complexities will of course effect the speed of the simulator.



<input type="checkbox"/> Help Level
<input checked="" type="radio"/> Full-on Auto
<input type="radio"/> First Simulation
<input type="radio"/> First Command
<input type="radio"/> Veteran
<input type="radio"/> Full manual control

HELP LEVEL

This sets the level of communications between you and the computer, with the following choices:

FULL-ON AUTO
FIRST SIMULATION
FIRST COMMAND
VETERAN
FULL MANUAL

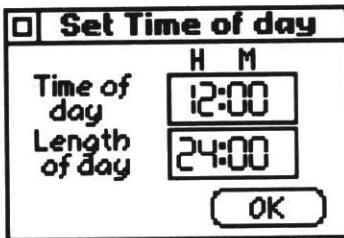
These help levels range from **NOVICE** to **EXPERIENCED VETERAN** with the most guidance offered at the **FULL-ON AUTO** level.

SET TIME OF DAY

This brings up a window of the same title, inside which are two main boxes, each with times in hours and minutes, entitled 'TIME OF DAY' and 'LENGTH OF DAY'.

TIME OF DAY allows you to set the time of day, based on Eastern Day-light Time, to whatever you require. This can come in useful, for example, if you're on the dark side of the planet trying to retrieve a satellite - setting the time to daylight hours in this instance would be extremely useful!

LENGTH OF DAY allows you to determine how long a day within the simulator takes in real time. For example, setting this to one minute, say, means that the Earth then rotates once a minute, i.e., you'll see 30 seconds of light and 30 seconds of darkness every minute of the mission.

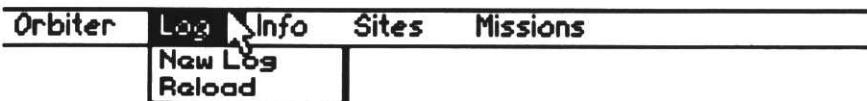


4. QUIT

Enables you to exit **SPACE SHUTTLE - THE SIMULATOR**.

NOTE: Pressing **ESC** while in the **MAIN MENU** also exits the program.

2. LOG



This menu provides you with many facilities both before, during and after missions. If you go straight into a mission without creating your own log, and then use the Log Save option once in flight, your log will be saved out as 'Vektor Graphix Ltd.'

'LOG' contains several options which enable you to maintain a Commander's log:

1. NEW LOG

Enables you to enter in your name as you're given command of a Space Shuttle Orbiter for the first time. After you've entered your name, your log is cleared and all subsequent missions will have their details logged.

You can save your log on auto or manual by pressing the appropriate button on this panel: auto means that the log is saved automatically, and manual allows you to save the log at any time you want, using the in-flight simulator menu log save facility.

Finally, when you insert your name in the box provided, it is always done in over-write mode, i.e., whatever you type in will automatically type over anything that is there already.

2. RELOAD

Enables you to reload a previously saved log from disk. Selecting this option brings up a window titled 'SELECT LOG FILE', which contains a list of all previously saved logs. Beneath this are two icons, 'ABORT', which takes you back to the MAIN MENU, and 'LOAD': to load an old log, simply select the one required from the list and then press 'LOAD'. This will then take you straight into the selected log. If a mission was in progress at the time the log was saved, then the mission is continued from that point.

3. INFO

Orbiter	Log	Info	Sites	Missions
			Crew Compartment Solid Rocket Boosters External Tank Main Engines Orbital Maneuvering System Reaction Control System Airlock & Payload Bay Remote Manipulator System Manned Maneuvering Unit	

This feature gives you information about the Space Shuttle itself, with a sub-menu containing many of the Orbiter's different aspects for further on-screen information.

Click on the required section, and a screen of illustrations and information comes on screen. At the bottom of these screens are three icons, in the form of book pages. These allow you to scroll forwards, backwards, and to return to the MAIN MENU.



More detailed information on these and other aspects of the Orbiter can be found in the REFERENCE SECTION.

4. SITES

This selection gives you two further options:

LAUNCH SITES

Orbiter	Log	Info	Sites	Missions
			Launch Site	Kennedy Space Center
			Land Site	Vandenberg Air Force Base

Allows you to see the two launch sites, KENNEDY SPACE CENTER, or VANDENBURG AIR FORCE BASE, in a short demo that zooms in from orbit down to the site in question. To return to the menu screen, simply press the ESCAPE key.

LANDING SITES

Orbiter	Log	Info	Sites	Missions
			Launch Site	Kennedy Space Center
			Landing Site	Vandenberg Air Force Base

This selection shows the two landing sites, KENNEDY SPACE CENTER and the primary site, EDWARDS AIR FORCE BASE, in the same way as the launch sites, by way of a short demo, which can be quit in the same way.

5. MISSIONS



This feature allows you to select which mission you wish to perform.

When you start with a new Commander, the only option available at the beginning is NEXT MISSION. Selecting this displays the mission objectives of the next full mission on the screen. Press 'ACCEPT' to start the mission, or 'ABORT' to cancel. During a full mission, Mission Control will expect you to be familiar enough with the Shuttle to respond to their commands.

As with all the missions in SPACE SHUTTLE - THE SIMULATOR, the first thing you see after selecting this mission is a page of mission text. At the bottom of the page are two buttons: 'ACCEPT', which you select to start the mission, and 'ABORT', which takes you back to the MAIN MENU. These icons don't appear if you're re-playing a mission.

This first training mission is entitled **ALT [747] MISSION**, and in it you'll launch from the back of a 747 transport plane near the glideslope for an unpowered landing at Edwards Air Force Base.

WARNING: on this first test mission, almost all the controls are set for you when on Full-On Auto. However, the LANDING GEAR isn't so don't forget to put it down! You will also be requested to turn on the Heads Up Displays.

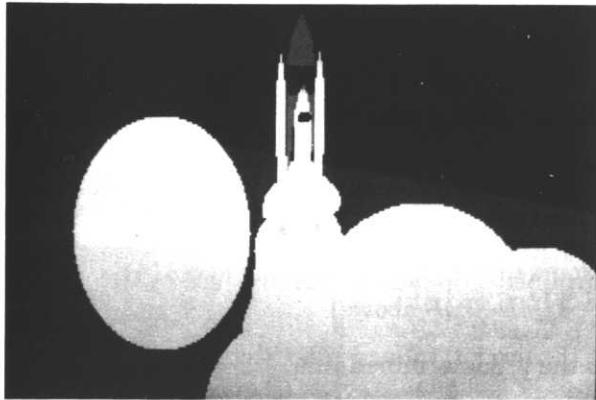
After completing this first mission, you'll see a screen entitled **MIS-SION OBJECTIVES**, which tells you how you fared in the mission.

When you click on OK at this screen, you're returned to the Main menu. Selecting missions again either allows you to run the mission again, either for fun or because you just failed it, or to continue onto the next one.

Once a full mission has been successfully completed, its objectives will be added to the Mission menu so that you can re-attempt a similar mission at any time in the future. As you become more experienced as a Commander, Mission Control will select you for more difficult missions.

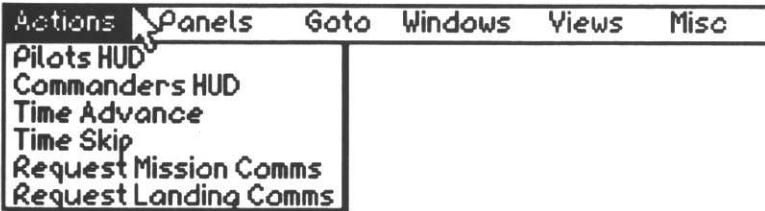
For a complete guide to the procedures within these missions, see 'MISSIONS - QUICK REFERENCE'.

SIMULATOR MENU



This menu is split into six categories:

1. ACTIONS



This menu allows you access to various primary in-flight commands:

PILOT'S HUD

With this feature you can turn the Pilot's **Heads Up** Display on or off without having to go to the respective panel.

COMMANDER'S HUD

Does the same as the above for the Commander's HUD.

TIMER ADVANCE

Allows you mouse access to this facility, offering two further sub-options:

ADVANCE - activates the facility according to the limits you've set [see **WINDOWS**, below]

ADVANCE, PAUSE TO NEXT COMMS - activates the timer advance, but only as far as the next communications from Ground Control, at which point it resumes the normal countdown.

TIME SKIP

Similar to **TIMER ADVANCE**, this feature again offers two sub-options:

SKIP - sets the pre-determined skip facility running [see **MAIN MENU, GAME SET UP, TIME SKIP** above.]

SKIP, PAUSE - skips to the predetermined time, then pauses until you're ready to continue.

TURN OFF COMMS - does just that. But beware, this is **not** for turning off the teleprinter. Using this switch means that you will no longer get any communications from Ground Control, and therefore means that you'll have no idea of what you're supposed to be doing. It also means that you cannot switch them back on again.

REQUEST MISSION COMMS

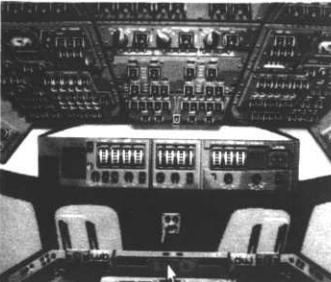
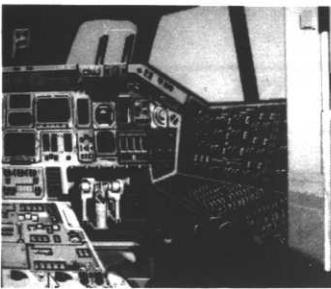
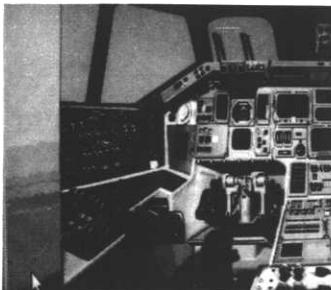
All missions within **SPACE SHUTTLE - THE SIMULATOR** begin after T+55 minutes. By this point, you'll have successfully launched the Shuttle into orbit, and prepared it for the mission. Now go to the **ACTION** menu, select **REQUEST MISSION COMMS**, and up they'll come, telling you everything you need to know about the progress of

the mission. If you select this before you're at the right point in time, the comms will tell you you don't need them just yet.

REQUEST LANDING COMMS

Once your mission is complete, you'll be ready to return home. As with the mission comms above, go to the **ACTION** menu, select **REQUEST LANDING COMMS**, and they will appear. As above, if you select them before time, you'll be told politely that they're not quite necessary yet.

2. PANELS



This is a quick way for you to get to the panel you want quickly [or to locate a particular panel if you're not sure where it is, of course]. Under this heading is the following list of panels:

FRONT PANEL
AFT PANEL
CENTER PANEL
LEFT PANEL
RIGHT PANEL
OVERHEAD PANEL
RIGHT AFT PANEL
LOWER AFT PANEL
OVERVIEWS PANEL

The last of these, **OVERVIEWS**, takes you to a series of diagrammatic representations of the Orbiter's operating stations. There are five of these that may be seen from the Pilot's point of view. Move the cursor around this and you'll find that the different panels are highlighted as you go over them. Click on the required panel with the left mouse button, and you'll be taken to it straight away.

Use the right mouse button or space bar to go to the next **OVERVIEW** screen: Once the last one has been displayed, it starts again at the beginning.

3. GO TO

This is similar to 'PANELS' above, except that **GoTo** offers you more detailed lists of the Orbiter's available Functions. For instance, Pilot's Instrument Power, Anti-Skid Light and so on. The full list is as follows:

FRONT

Actions		Panels			
		Goto	Windows	Views	Misc
Front		Pilots Instrument Power			
Aft		Air Data			
Cent		ADI switches			
Left		Landing Gear			
Right		CSS buttons			
Over		Pilots HUD power			
Right		Commanders HUD power			
Lower		CRT displays			
		NWS Fail light			
		Anti-Skid Light			

AFT

Actions		Panels			
		Goto	Windows	Views	Misc
Front					
Aft		-2 Sense			
Cent		Payload Latches			
Left		Payload Select			
Right		RMS Camera PORT			
Over		CCTV camera selects			
Right		RMS Joints			
Lower		RMS Power			
		RMS Select			
		Port RMS Latches			
		Port RMS Deploy			

CENTER

Actions		Panels			
		Goto	Windows	Views	Misc
Front					
Aft					
Cent		CRT Power ON/OFF			
Left		Left Crt Sel 1,3			
Right		Right Crt Sel 3,2			
Over		OMS Eng Left/Right			
Right		BFC Crt Select			
Lower		Air Data Probes Exhibit			
		Orbital Dap			
		SRB Separation			
		ET Separation			
		S-Band PM Antenna			
		Air Data Probes Dpu/Stw			

LEFT

Actions		Panels			
		Goto	Windows	Views	Misc
Front					
Aft					
Centre					
Left		Cabin Relief			
Right		Cabin Vent			
Over		AntiSkid ON/OFF			
Right		Nose Wheel Steering			
Lower-Aft					

RIGHT

Actions	Panels	Goto	Windows	Views	Misc
		Front			
		Aft			
		Centre			
		Left			
		Right	HE Isolation Valves		
		Over	APU Operate		
		Right	APU Speed Select		
		Low	HYD Main Pump Press		
			HYD Circ Pump		
			APU Cntrl Pwr		
			APU Fuel TK VLV		
			APU Auto Shut Down		
			APU Fuel		
			Boiler Cntrl/Htr		
			Boiler Pwr		
			Boiler N2 Supply		
			ET Umbilical Door		
			LG HYD Isol Valves		

RIGHT AFT

Actions	Panels	Goto	Windows	Views	Misc
		Front			
		Aft			
		Centre			
		Left			
		Right			
		Overhead			
		Right	Payload Bay Doors		
		Low	Bay Door Radiators		
			KU Band Antenna		
			KU Band Direct Stow		

OVERHEAD

Actions	Panels	Goto	Windows	Views	Misc
		Front			
		Aft			
		Centre			
		Left			
		Right			
		Over	GPC Swithes		
		Right	DEU switches		
		Low	TACAN 1 2 3		
			Aft Left RCS		
			Aft Right RCS		
			Left RCS Crossfeed		
			Right RCS Crossfeed		
			Master RCS Crossfeed		
			OMS Switches		
			Left Audio		
			Right Audio		

LOWER AFT

Actions	Panels	Goto	Windows	Views	Misc
		Front			
		Aft			
		Centre			
		Left			
		Right			
		Overhead			
		Right-Aft			
		Low	Jettison RMS		
			Jettison KU Band		

4. WINDOWS



This allows you access to all the various in-game set up windows available within the MAIN MENU. These are as follows:

TIME ADV

- see TIMER ADVANCE in MAIN MENU.

TIME SKIP

- see TIME SKIP in MAIN MENU.

TIME OF DAY

- see SET TIME OF DAY in MAIN MENU.

MET

Short for MISSION ELAPSED TIMER, this brings up a window showing the time elapsed so far on the current mission. This can be moved to any desired point on the screen simply by clicking and holding the mouse pointer onto the top of the window and moving it around. To remove the MET, simply click on the small box in the top left hand corner of the window.

COMPLEXITY

- see DETAIL COMPLEXITY in MAIN MENU.

FIXED VIEWS

Brings up a window with a list of all the different fixed views available - note that these are not available once in orbit.

Once you have chosen a view, pressing F8 will select the chosen view as the default for the F8 key for the rest of your current stay within **SPACE SHUTTLE - THE SIMULATOR**.

HELP LEVEL

See HELP LEVEL in MAIN MENU. Note*: Help Levels cannot be increased once a simulation has been started. Help Levels can only be reduced during an ongoing simulation.

LOG OPTIONS

Brings up a window of the same name. The 'AUTO log save time' feature will allow you to set the time that the log is saved, i.e. every 5 minutes, every 10 minutes and so on. Of course, this only applies if you choose to have the log saved automatically. At the bottom of the window are three buttons, 'M', for MANUAL LOG save, 'A', for AUTO LOG save, and 'OK', which quits the window when you've finished using it. If you wish to save any new configuration, you must use the OK button - clicking the 'Close Window' button at the top of the box will simply abandon any changes you might have made.

You will notice that this LOG OPTIONS window is very similar to the NEW LOG window in the MAIN MENU. This feature will allow you to set up your log options at any point during **SPACE SHUTTLE - THE SIMULATOR**, and, if required, change them again at any other point.

5. VIEWS

Actions	Panels	Goto	Windows	Views	Misc
				Comm HUD	F2
				Pilots HUD	Sh F2
				Left	F3
				Right	Sh F3
				Left Over	F4
				Right Over	Sh F4
				Left Aft	F5
				Right Aft	Sh F5
				Inside MMU	F6
				View MMU	Alt F8
				CCTV	F9
				View Crawler	Sh F9
				View 747	Alt F9
				View Shuttle	F10
				Left SRB	Sh F10
				Right SRB	Alt F10
				View ET	Sh F7
				TelePrinter	F7

Gives a submenu of all the different viewpoints available. Selecting any one of them will take you to the viewpoint selected.

6. MISC [miscellaneous]

Actions	Panels	Goto	Windows	Views	Misc
					Pause .P
					Log Save ^LS
					Main Menu ^QY
					Quit to DOS ^QD

PAUSE

Pauses the simulator. Press again to unpause .

LOG SAVE

Saves and updates the current log, overwriting any old data.

MAIN MENU

Stops the simulator and returns to the MAIN MENU.

QUIT TO DOS

Stops the simulator and quits to MSDOS [not Amiga/ST].

Controls and Instrumentation

This section is split into three main areas - LAUNCH, ON-ORBIT OPERATIONS and LANDING. Similar to the reference section, any function that occurs in more than one stage of the mission will be described in detail in the section in which it's first used.

1. LAUNCH

CRT DISPLAY SYSTEM

LEFT/RIGHT CRT SEL [PANEL C2] - select which CRT the display will be on:

LEFT CRT SEL -	POSITION 1: left keyboard controls left CRT1 POSITION 3: left keyboard controls center CRT3
RIGHT CRT SEL -	POSITION 2: right keyboard controls right CRT2 POSITION 3: right keyboard controls center CRT3
LEFT & RIGHT CRT SEL -	POSITION 3: both keyboards interleaved onto center CRT3

CRT1/2/3 POWER ON/STANDBY/OFF [PANEL C2] - supplies power to the CRTs from the main buses [MNA/B/C]. STANDBY warms the CRT filament up, while ON supplies full power. The CRT4 switch on PANEL R12 does the same thing for the aft CRT.

CRT 1/2/3 MAJ FUNC [PANEL C2] - tell the GPC which of the different software it should be using, whether Guidance, Navigation & Control [GN&C], Systems Management [SM] or Payload Bay operations [PL]. CRT4 has the same switch.

DISPLAY ELECTRONICS UNIT 1/2/3/4 [PANEL O6] - switch to LOAD to initiate a GPC request for data stored in the mass memory.

NOTE

1. If you have a CRT selected, then moving to that CRT and pressing the ALT key will bring up an overlaid window containing the Orbiter's computer keypad.
2. For the purposes of **SPACE SHUTTLE - THE SIMULATOR**, the aft CRT and keyboard won't be functional, with one exception: you will, by using the + and - keys on your computer keypad, as opposed to the keypad on PANEL C2 within the simulator, be able to scroll through and view, but not utilize, all 29 CRT displays used by the real Shuttle. **SPACE SHUTTLE - THE SIMULATOR** will only be using a limited number of the actual displays, primarily those concerned with take-off and landing. We hope to bring a more complete display system to future versions of the simulator.

GENERAL PURPOSE COMPUTERS [GPCs]

- see reference section.

ORBITAL MANEUVERING SYSTEM

- see reference section

AUXILIARY POWER UNITS

- see reference section

MAIN PROPULSION SYSTEM

- see reference section

SOLID ROCKET BOOSTERS [SRBs]

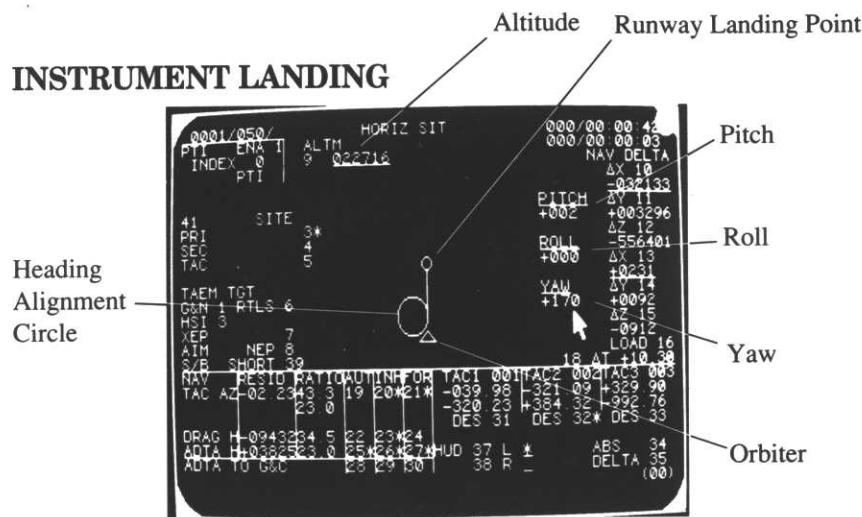
- see reference section

EXTERNAL TANK

- see reference section

GUIDANCE, NAVIGATION AND CONTROL

INSTRUMENT LANDING



When landing the Orbiter and especially when attempting the 'INSTRUMENT LANDING' mission in which you must bring the Orbiter down on instruments alone, there are certain instruments to keep your eye on. As far as **SPACE SHUTTLE - THE SIMULATOR** is concerned, the most important instrument to monitor is the SPEC 50 CRT display, as illustrated above.

The SPEC 50 display shows the pilot everything he needs to know when landing blind. Basically, the large circle displayed on the screen is the Heading Alignment Circle [HAC], is what you must aim for when descending. The little symbol nearby is the position of the Orbiter, and the small circle attached to the large circle is the Runway Touchdown Point, which is the optimum point on the runway for you to touchdown [the end nearest you, basically - the Orbiter needs a lot of space to land.]

As well as these graphics, there are readouts for Pitch, Roll & Yaw, as well as Attitude and Speedbrake settings.

To access this display, press SPEC 50 PRO on the keypad [PANEL C3]. However, when CRT3 is turned on, SPEC 50 is the default display.

Aside from this, the other instruments to watch are the ADI, to make sure you're coming in straight; the HSI, to make sure you're nose is where it should be; the Radar Altimeter, to keep an eye on your

attitude, and the AVVI, to make sure you're not shedding attitude too fast. Then there's the AMI, to make sure you're not coming in too fast, and finally, of course, the Speedbrake, just in case you are coming in too fast.

For a detailed description of manual instrument landing procedures, see MISSION PROCEDURES, RE-ENTRY [MM304] and onwards. In fact, it is a good idea to read this before attempting any kind of landing procedures.

1. TACAN

Although TACAN is normally used to guide the Orbiter in on Auto, in **SPACE SHUTTLE - THE SIMULATOR** you're just going to have to do without and land on manual. For details of the TACAN system, however, see reference section

2. INSTRUMENTS

AIR DATA SYSTEM

- see reference section

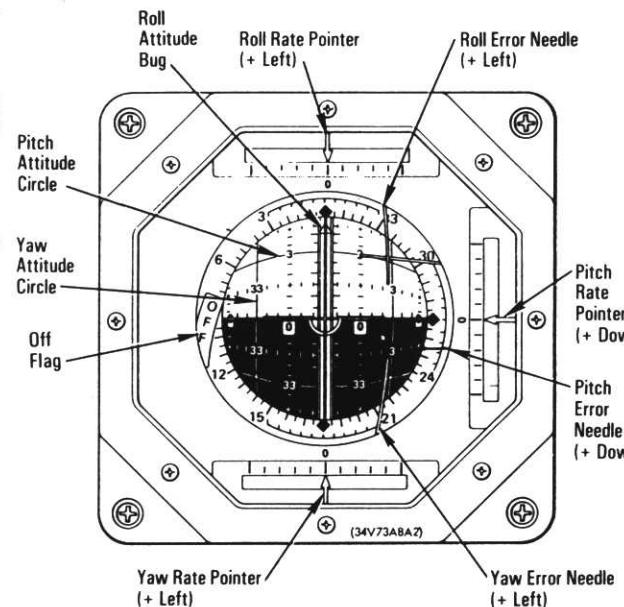
RADAR ALTIMETER

- see reference section

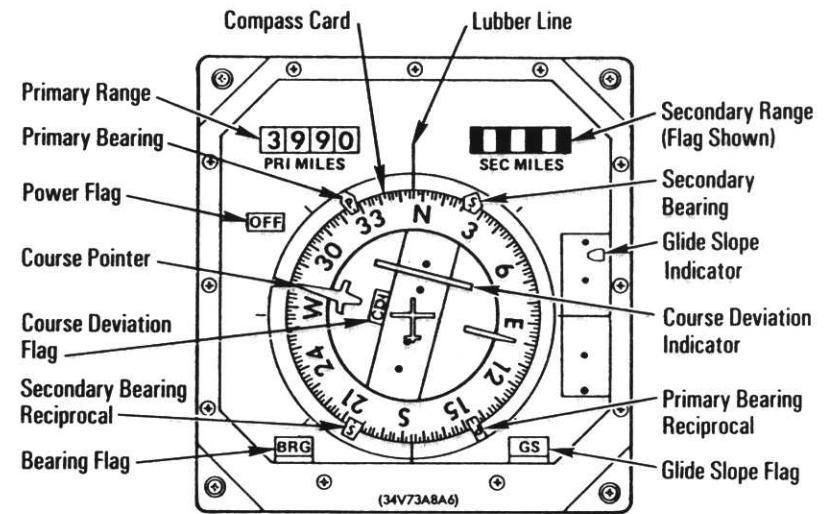
ATTITUDE DIRECTION INDICATOR

The attitude shown is determined by the setting of the ADI - ATTITUDE switch on PANEL F8. The Local Vertical/Local Horizon [LVLH] setting shows the attitude in relation to Earth. The INRTL setting shows the attitude in relation to the inertial guidance systems and is relative to "fixed" items in space such as stars. The REF position shows the attitude relative to the attitude the last time the ATT REF switch [PANEL F8] was depressed [this is useful for returning to a previous attitude after a maneuver].

Each ADI has three rate pointers which show the Orbiter's roll [top indicator], pitch [side] and yaw [bottom] rates. The ADI RATE switches control the range of these indicators [full scale deflection at the HIGH setting indicates 10 degrees per second, MED is 5 deg/sec and LOW is 1 deg/sec]. The pointers are "fly to" which means that you have to move the RHC towards the pointer to null the effect. During maneuvers, the error between the target attitude and the current attitude is shown by the pitch, roll and yaw needles over the ADI ball. These needles are "fly to" which means that the correct attitude is achieved by flying in the direction of the needles until they cross at the center of the ball.



HORIZONTAL SITUATION INDICATOR



The HSI SELECT switches on PANELS F6 and F8 control the mode of the associated HSI:

The MODE switch selects the flight phase: ENTRY, TAEM and APPROACH. However, for the most efficiency in **SPACE SHUTTLE - THE SIMULATOR**, only one mode is used for all purposes.

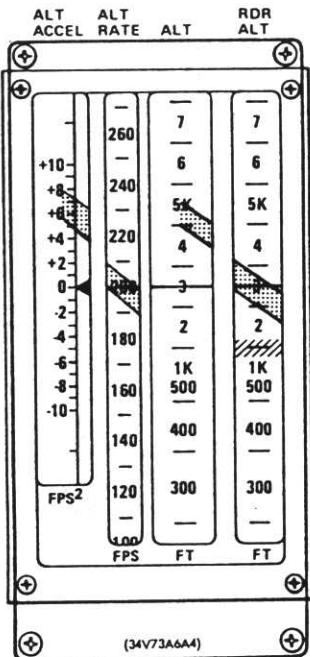
The SOURCE switch selects the source which drives the instrument: TACAN, inertial navigation [NAV] or Microwave scan beam landing system [MLS].

The Orbiter heading is shown at the top of the compass, read at the "lubber" line. The Course pointer indicates the direction of the programmed course. The course deviation indicator is "fly to" and shows the required track relative to the current Orbiter position. The CDI flag appears if the indicator display is invalid.

Another "fly to" indicator is the glide slope indicator which shows the height of the Orbiter relative to the ideal height at that point on the glideslope. The glideslope indicator is valid after re-entry until about 1500 feet. It is invalid when the GS flag shows on the HSI. The Primary and Secondary bearing pointers show the relative position of 2 programmed bearings and are valid unless the BRG flag appears. The primary range and secondary range counters show the distance in nautical miles from a reference source [normally the runway]

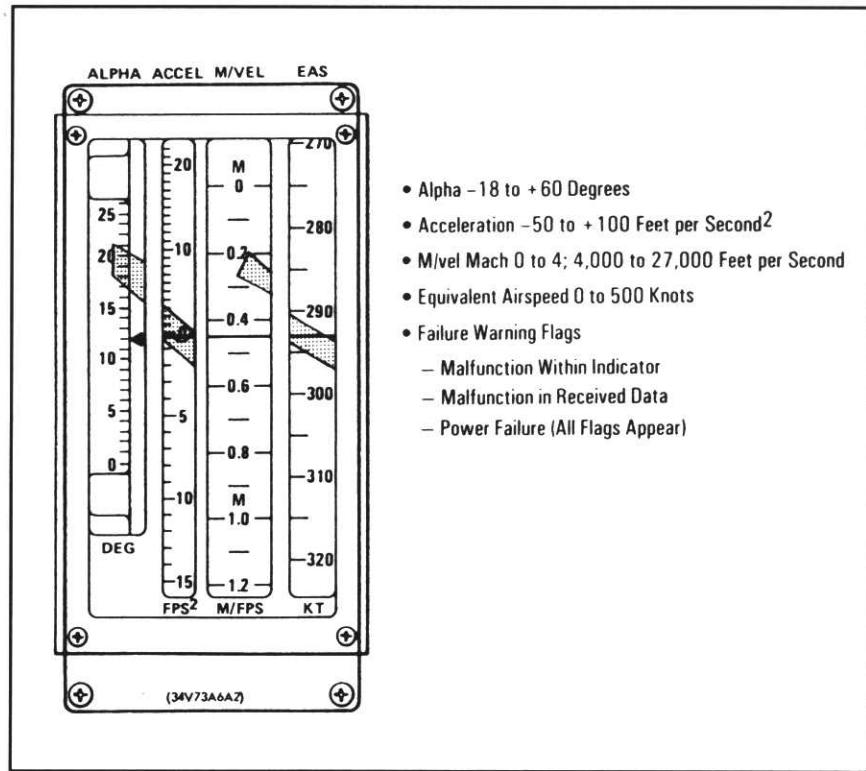
during the later stages of the flight]. The maximum TACAN range is about 3999 nautical miles, but is generally not selected until after blackout, and the MLS range is 20 nautical miles, usually used once on the heading alignment cylinder. On initial entry, NAV is the normal selection.

ALTITUDE AND VERTICAL VELOCITY INDICATOR



The above indicators are only valid after the deployment of an air data probe using one of the AIR DATA switches below a speed of Mach 3, usually occurring just before landing. One of two radar altimeters can be selected using the RADAR ALTM switch on PANEL F6/F8. For details of probes, see Air Data Probes.

ALPHA MACH INDICATOR



- Alpha -18 to +60 Degrees
- Acceleration -50 to +100 Feet per Second²
- M/vel Mach 0 to 4; 4,000 to 27,000 Feet per Second
- Equivalent Airspeed 0 to 500 Knots
- Failure Warning Flags
 - Malfunction Within Indicator
 - Malfunction in Received Data
 - Power Failure (All Flags Appear)

The Alpha Mach Indicators [AMIs - PANELS F6/8] show four separate readings:

ALPHA, shows the vehicle angle of attack relative to the ground; ACCEL, shows the acceleration or deceleration along the flight path; M/VEL, shows the velocity either in terms of thousands of feet per second up to 2000 fps, or as a Mach number where Mach number = $V_{REL}/1000$; EAS, shows the velocity as an equivalent airspeed in knots.

As with the AVVI, each scale shows an OFF flag if the indicator malfunctions.

SURFACE POSITION INDICATORS

- see reference section

RCS COMMAND LIGHTS

- see reference section

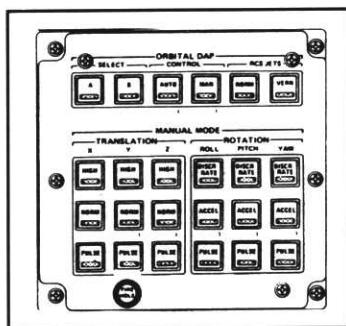
G FORCE METER

- see reference section

HEAD UP DISPLAY

The Commander and Pilot HUDs are enabled by the HUD POWER switches on PANEL F3. For a full description of the HUD's various elements, see reference section.

DIGITAL AUTO-PILOT



By switching on the ORBITAL DAP MAN switch on PANEL C3, the Commander and Pilot can override the DAP if they wish to have manual control or in a contingency situation. NOTE: The Orbiter is "fly by wire" so even when under manual control, the manual commands are still processed by the computer.

1. SELECT

These two buttons determine the amount of thrust, as well as which combination of jets to be fired, for any given operation. 'A' normally allows higher thrusts than 'B'. In **SPACE SHUTTLE**, we only use 'A'. However, we do allow you to toggle between them even though it won't alter anything.

2. AUTO/MAN

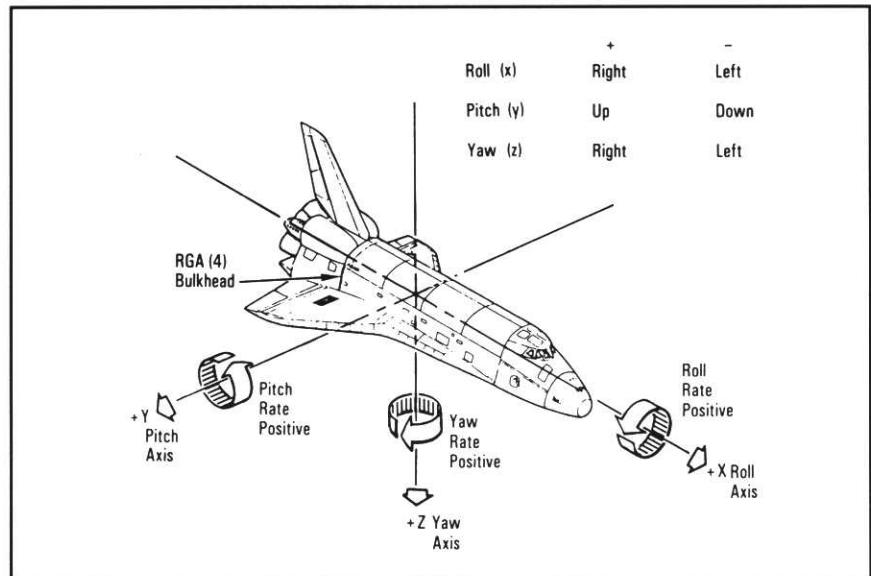
Once in MAN you can translate and rotate the Orbiter using the RCS jets. While in AUTO the Orbiter is under computer control: however, for game purposes, all in orbit maneuvers are performed in manual.

3. NORM/VERN

Vernier jets fire with approximately one quarter the strength of the Normal jets and are mostly used for fine positioning. Ordinarily if you're tracking a satellite over a large distance you should use the NORM jets and then switch to the VERN jets when you attempt to grab the satellite with the RMS.

4. TRANSLATION

The term *translation* means to physically move the Orbiter, for example, Left, Right, Up and Down etc. The Orbiter can move on 3 axes, X, Y and Z. Simply, X is either Forwards or Backwards, Y is Left or Right and Z is Up or Down.



There are 9 translational buttons split into 3 columns of 3. You'll notice that each column is headed with the letters X, Y and Z. HIGH, NORM and PULSE. NORM results in continuous jet firings, giving the effect of constantly increasing the relevant translational rate. When PULSE is selected for any given axis, a single burst of jet fire is produced with each key press. HIGH has the same effect as NORM.

5. ROTATION

The term *Rotation* means to spin the Orbiter on any axis about its center. There are 9 rotational buttons split in to 3 columns of 3. You'll notice that each individual column is headed with the letters ROLL, PITCH and YAW. Each column has the buttons DISC RATE, ACCEL and PULSE. Simply, when DISC RATE is selected, jet firings continue for as long as the key is depressed and will rotate at no more than a rate of 4 degrees per second if NORM is selected and 1 degree per second if VERN is selected. When ACCEL is selected, continuous jet firings are made until the key is released; this has the effect of constantly increasing the relevant rotational rate. When PULSE is selected for any given axis, a single burst of jet fire is produced with each key press.

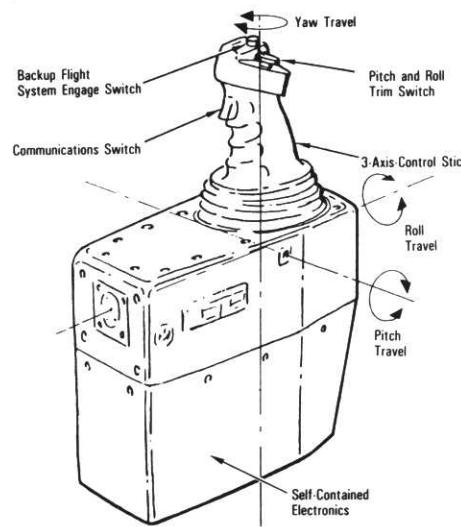
With both the Rotation and Translation buttons each axis is independent of the other so you could have PITCH in PULSE mode while ROLL is in ACCEL or alternatively you could have X in NORM while Z is in PULSE.

As you become more experienced at flying the Orbiter you will find the DAP very useful.

FURTHER REFERENCE

See also GPC for flight phases

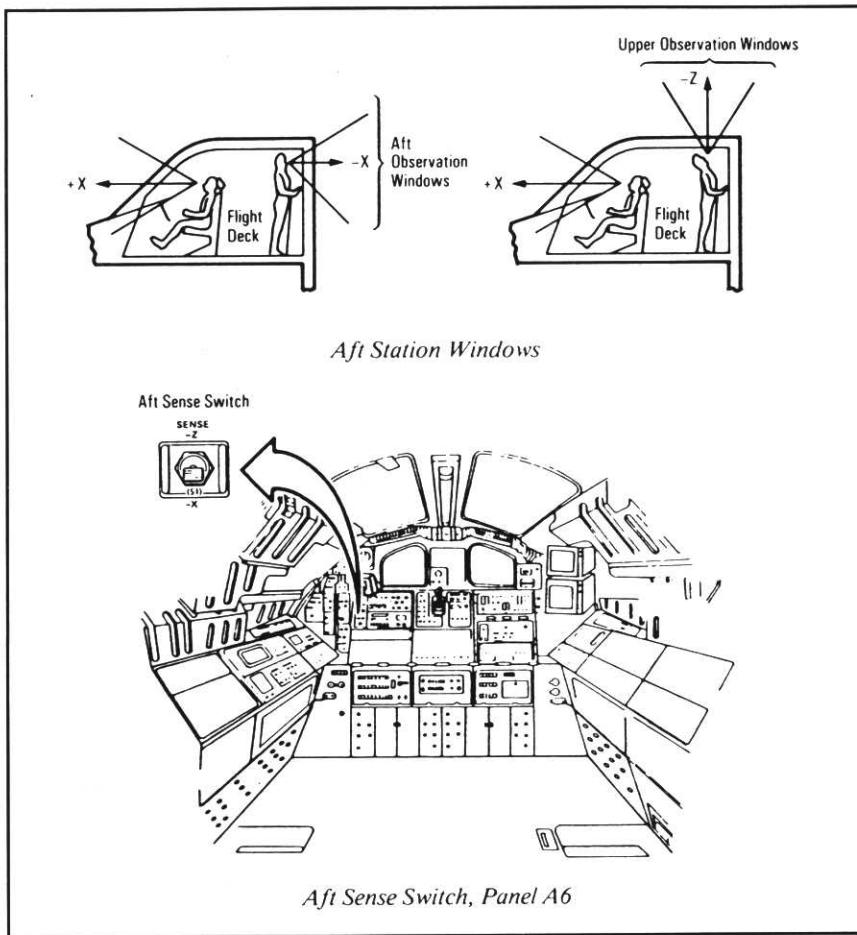
ROTATIONAL HAND CONTROLLERS



When the controllers are enabled by the FLT CNTLR switches on PANEL F6 [Commander], F8 [Pilot] and A6 [aft], using the RHC will override automatic mode and pass control to manual mode. The only exception to this is in the ascent stage where the stick must be enabled by pressing the CSS buttons for pitch and roll/yaw on PANEL F2 [Pilot] or PANEL F4 [Commander]. The AFT SENSE switch on PANEL A6 is used to switch the sense of the aft control stick so that movements are along the line of sight of the user, instead of working backwards, as they would normally appear to do.

RHC Use	Forward RHC Use- Commander and Pilot	Aft Line-of Sight Reference Aft RHC Use Sense Switch -X	Overhead Line of Sight Reference: Aft RHC Use Sense Switch -Z

Visualize RHC Mounted on Same Plane as -X Windows



If a failure is detected in the Pilot's or Commander's RHC, the red RHC warning light on PANEL F7 is illuminated.

The guarded button on the RHCs engage the BFS and should only be used in contingency situations: however, this won't be an operational option for users of **SPACE SHUTTLE - THE SIMULATOR**.

SPACE SHUTTLE - THE SIMULATOR can accept RHC control from the keypad/cursor keys. Moving the cursor up/down (8/2) controls movement in the pitch axis. Moving the cursor left/right (4/6) controls roll movement. Unfortunately, computer keyboards aren't as advanced as the Space Shuttle RHCs, so yaw movement is controlled by the , . keys. The simulator treats the keypad as an RHC during ascent, insertion, de-orbit, re-entry and landing [during orbit, it's treated as a Translational Hand Controller].

To switch between the two controllers, press F to access the Front RHC and A for the Aft RHC.

However, only the two front RHCs will be operable during flight phases: only during on-orbit maneuvers will you be able to transfer control to the aft RHC.

TRANSLATIONAL HAND CONTROLLERS

The controllers are enabled by the FLT CNTRL switches on PANEL F6 [Commander] and A6 [aft], and for the same reasons as for the RHCs, the AFT SENSE switch on PANEL A6 is used to switch the sense of the aft THC.

USER CONTROL

SPACE SHUTTLE - THE SIMULATOR can accept THC type control from the keypad/cursor keys. As with the RHCs [above], moving the cursor up/down (8/2) controls movement in the pitch axis, moving the cursor left/right (4/6) controls roll movement, and yaw movement is controlled by the , and . keys. The simulator treats the keypad as a THC during orbital maneuvers [during ascent, insertion, de-orbit, re-entry and landing it's treated as an RHC]. As with RHCs, the aft THC is only available during on-orbit operations.

RUDDER PEDALS

The rudder pedals are enabled by the FLT CNTRL switches on PANEL F7 [Commander] and F8 [Pilot].

SPACE SHUTTLE - THE SIMULATOR accepts rudder control using the same , and . keys as for in space [yaw left/right], but won't be simulating the braking abilities of the rudder pedals in this version.

THRUST AND BRAKING

When under control of the GPCs, the SPD BK/THROT button lights on PANELS F2 and F4 indicate AUTO. To take control of the thrust/brakes, the Pilot must depress the takeover switch on his thrust controller and move the lever until its setting matches the last computer thrust [or brake] setting. Manual control is now attained and the SPD BK/THROT lights indicate MAN.

The takeover switch can now be released. Control can be restored to the computers by pressing the SPD BK/THROT button.

Thrust/speed brake control is enabled by the FLT CNTRL switches on PANEL F7 [Commander] and F8 [Pilot].

The speedbrake /throttle within SPACE SHUTTLE - THE SIMULATOR doesn't need to be 'taken over', as it is permanently available. Use the -/= keys on the keypad to take control of the throttle or speedbrake.

BODY FLAP

- see reference section

RHC/PANEL ENABLE/INHIBIT

- see reference section

2. ON-ORBIT MANEUVERS

ORBITER

- see reference section

CREW COMPARTMENT

- see reference section

AIRLOCK

- see reference section.

PAYLOAD BAY

PAYLOAD BAY DOORS

Before you can open the doors, you have to enable the AC motors, which are labelled PL BAY DOOR, SYS 1 and SYS 2. The payload

bay door control switches are located on PANEL R13L. Power is initiated to the payload bay door power and control systems by switching the PL BAY DOOR switches to ENABLE and setting the LATCH CONTROL OPEN/CLOSE switch to OPEN. This then initiates the automatic sequences, and the PL BAY DOOR indicator shows the door status. Procedure time is 64 seconds, during which the indicators will be at BARBERPOLE. The closing procedure is the same in reverse, setting the switch to CLOSE instead of OPEN. The STOP position stops the sequence in progress.

PAYLOAD BAY RADIATORS

Releasing the radiators allows heat to escape from the Orbiter. Deployment is a two stage operation, as the radiators are latched down for safety reasons. Before releasing the latches you first have to enable the power. To do this, click the PL BAY MECH PWR SYS1 and SYS 2 switches to ENABLE. Only enabling one of them will halve the speed at which both the latches and the radiators deploy.

Once powered, release the STBD and PORT latches by clicking the LATCH CONTROL SYS A and SYS B switches to RELEASE. The indicators above the switches will now be on BARBERPOLE. When the latches are released, these indicators will show REL.

To deploy the radiators click the RADIATOR CONTROL SYS A and SYS B switches to DEPLOY. Once deployed, the indicators will show DPY.

MANNED MANEUVERING UNIT

SPACE SHUTTLE - THE SIMULATOR allows you to have full control over the MMU when one is being carried by the Orbiter. Once you are in orbit, and you have accessed the Mission Comms, the MMU is utilized by simply selecting MMU from the VIEWS option, or by pressing F6. You'll now be transferred inside the unit, without any worries about any 3 hour pre-breathing operation. Obviously, it can't be used at any time other than in orbit.

Next, press Shift F6, and the unit will unlatch from the cargo bay wall [Alt F6 re-latches it on returning to the bay]. We have assigned unique keys that control the Rotation and Translation of the MMU. This way you can control the MMU while viewing it from any other angle, for example, out of the Aft Payload Bay windows.

PAYOUT DEPLOYMENT & RESCUE

- see MISSIONS, QUICK REFERENCE.

REMOTE MANIPULATOR SYSTEM

In **SPACE SHUTTLE - THE SIMULATOR**, only the port RMS arm is used, although you still have to select it. To do this, use the RMS SELECT switch on PANEL A8L. Next, energize the RMS by using the RMS POWER switch. For Player Controls, see KEYBOARD CONTROLS above.

During launch, the arm is latched at the shoulder, but doesn't need to be relatched for re-entry and landing. The shoulder brace latch is released once in orbit using the switch on PANEL A8 to release the arm. This switch must be held over until the associated indicator turns grey [about 6-9 seconds].

The arm is deployed to its operational rest position after the payload doors are opened and stowed again before they are closed using the appropriate DEPLOY/STOW switch on A8L. Deployment and stowage take about 34 seconds. The status of the arm is shown by the indicator above the relevant DEPLOY/STOW switch.

When deployed, the arm must be latched until it's needed for use using the appropriate LATCH/RELEASE switch. The AFT, MID and FWD READY FOR LATCH indicators turn grey when the arm is deployed and in position for latching and the LATCH/RELEASE switch is then activated.

The indicator above the switch changes to LAT when the arm is latched.

RMS CAMERAS

The RMS-related CCTV system consists of four cameras in the payload bay, all of which can be panned and tilted. However, since **SPACE SHUTTLE - THE SIMULATOR** only uses the Port RMS arm, it only uses the two Port cameras.

To select, use the RMS PORT switch on the VIDEO INPUT section of the AFT Panel, then set the RMS CAMERA switch, below the AFT RHC, to either WRIST or ELBOW.

STANDARD END EFFECTOR

- see reference section

JETTISONING THE ARM

- see reference section

COMMUNICATIONS

KU BAND ANTENNA

DEPLOY [PANEL R13] - deploys the KU antenna, ensuring that the payload bays are open first, of course. The indicator above the switch shows the current status of the antenna. Stowage is the reversal of deployment - both operations take about 20 seconds.

DIRECT STOW [PANEL R13] - In contingency situations the antenna can be stowed using this override switch. If this still fails, the antenna can be jettisoned, using the same routine as for RMS jettison [above], except that the Antenna is not jettisoned, but merely released. The Orbiter then must simply maneuver away from it.

CLOSED CIRCUIT TELEVISION SYSTEM [CCTV]

All cameras are linked into monitors on Panel A3, from which you can select the desired cameras, as well as pan and tilt them.

The view on Panel A3 is in mono.

3. LANDING

LANDING GEAR

The landing gear is deployed by the Commander or Pilot pressing guarded switches ARM and DN on PANEL F6 or F8. The landing gear status is shown on indicators above these switches. The landing gear deploy and nose wheel steering is powered by hydraulic system 1. If there is a hydraulic [or other] failure and the gear fails to start to deploy, within one second pyrotechnic jets fire to deploy the gear. If hydraulic system 1 fails, the Orbiter is steered after landing by differential braking on the main gear [powered by hydraulic systems 2 and 3]. Loss of hydraulic systems 1 and 3, or 2 and 3, would result in a loss of half the braking pressure on each wheel, and would require an increased braking distance on landing. There is nothing you can do about it except brake harder and earlier!

The nose wheel is steered either by the GPCs or, in contingency situations, by the control stick or rudder pedals. The mode is selected by setting the NWS switch on PANEL L2 to DIRECT. However, the nose wheel steering is still effected by failures to the Hydraulic Systems.

3. Reference Section

This section gives a description of, and any necessary background to each and every part and function of the Space Shuttle, as used in SPACE SHUTTLE - THE SIMULATOR.

The reference section is split into three major activities, LAUNCH, ON-ORBIT OPERATIONS & LANDING, with each aspect of the Shuttle being covered under that section for which it has the most relevance. In the case of an item being equally as important to more than one stage of the Shuttle's activities, we have given the full description and background, where applicable, in the first such occurrence.

For easy access to any one part of the Shuttle, refer to the main index at the back of this manual.

- SUMMARY OF PANELS

The controls and instrumentation of the real Space Shuttle are understandably complex. SPACE SHUTTLE - THE SIMULATOR accurately reproduces the layout and functions of all of the genuine primary Shuttle controls.

The **FLIGHT DECK** is split into two main stations:

The **FORWARD** station, at which are seated the Commander [right] and the Pilot [left].

The **AFT** station, from which the RMS is controlled during orbit.

The instrument panels are labeled according to their position:

F front PANEL
O overhead PANEL
L left PANEL
R right PANEL
C center PANEL
A aft PANEL
M right aft PANEL
N lower aft PANEL

FORWARD PANEL

F2 Commander's control panel - CSS/AUTO buttons, Speed Brake controls etc.
F3 HUD power, Trim controls
F4 Pilot's control panel - as F2
F6 Commander's main panel - landing gear, direction/attitude indicators etc.
F7 CRT main panel, pressure gauges
F8 Pilot's main panel - as F6

LEFT PANEL

L1 Fire suppression
L2 Nose Wheel Steering, Anti-Skid controls & Life Support

CENTER PANEL

C2 Keypads, CRT controls
C3 DAP, SRB/ET Sep, Air Data probe controls etc.

RIGHT PANEL

R1 Power Distribution
R2 APU/Hydraulics/ET Umbilical
R4 MPS/Hydraulics
R12 Keypad/CRT, fuel/water
R13L PLB/MMU/KU antenna

OVERHEAD PANEL

O1 GPC status, Press/Temps
O3 RCS/OMS Press, Timers
O5 Pilot's communications controls
O6 GPCs, Star Tracker
O7 Tacan, RCS
O8 Radar Altimeter, OMS
O9 Commander's communications controls

AFT PANEL

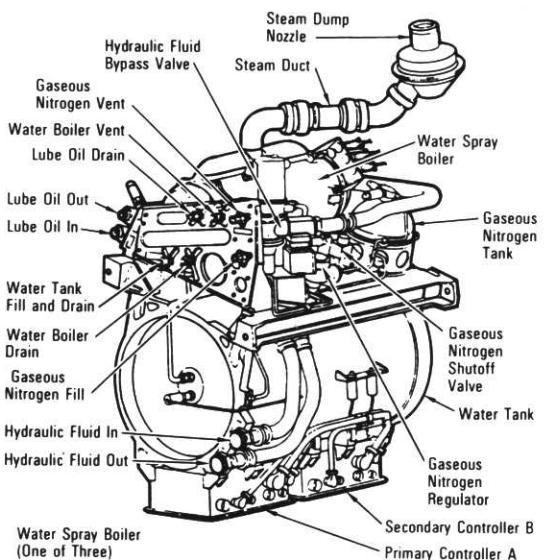
A3 CCTV monitors
A4 Timers
A6 Orbital DAP
A7 Video Control, RHC
A8 RMS controls
A14 RMS Arm & KU Antenna jettison controls

A full description of all panels used in SPACE SHUTTLE - THE SIMULATOR can be found with the other indices at the end of this manual.

1. LAUNCH

WATER SPRAY BOILERS

These are located in the aft fuselage of the Orbiter, and are used to cool down the power unit, lube oil and hydraulic systems during both the ascent and de-orbit phases. There are three boilers in all, and they store water in a bellows-type storage tank pressurized by gaseous nitrogen.



Along with the three APUs and the hydraulic pumps, the water spray boilers are in operation five minutes before take-off, although the boilers are pre-activated forty-five minutes before this. One of these boilers is also opened briefly one day before de-orbit during a flight control system checkout.

BOILER N2 SUPPLY 1/2/3 [PANEL R2] - controls the nitrogen shut-off valves, which maintain water pressure in the boilers.

APU FUEL / H2O QTY [PANEL F8] - allows the water quantity of each boiler to be displayed on the 1/2/3 METERS on the same panel.

1/2/3 [PANEL R2] -

i] operates the two boiler controllers. When the relevant switch is at POSITION A, the A controller for that boiler is powered, and likewise for POSITION B. When at OFF, electrical power is removed from both controllers.

ii] operates the electrical heaters when in orbit to prevent water freeze up in orbit. The heaters apply to the same boilers as do the power switches, and the access method is also the same.

1/2/3 [PANEL R2] - enables [i.e., provide the automatic control functions for] the relevant controller selected by the previous switch [above]. When enabled, the ready signal appears on the corresponding APU/HYD READY TO START talkback indicator on PANEL R2, as long as the following has been actioned: N2 shut-off valve is open, steam vent nozzle temperature is >130 F, and the hydraulic fluid bypass valve is in the correct position with regard to the hydraulic fluid temperature.

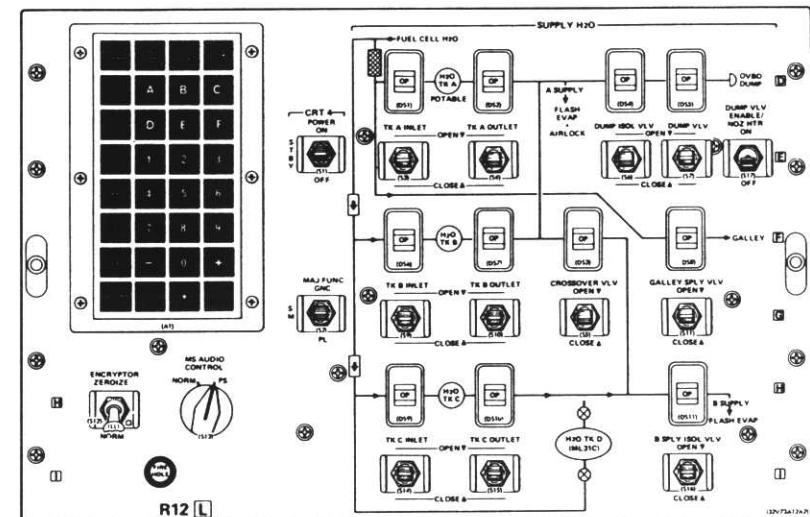
FURTHER REFERENCE

See also LANDING GEAR.

PROBLEMS

As the boilers and heaters are immediately concerned with the smooth running of the APUs on ascent, you must check to make certain that they are reading and operating correctly at all times. Once the pilot has initiated the APU pre-start sequence, he confirms that the water spray boilers are activated before he does anything else. At T-5 minutes the pilot starts the three power units by setting the APU CNTL switches to START/RUN and checking the hydraulic pressure gauges for an indication of approximately 600-1000 psi. He then pressurizes the main pump and looks for approximately 3000 psi on the gauges. All three hydraulic main pump pressures must be greater than 2800 psi by T-4 minutes or the automatic launch sequencer will abort the launch. This is not something that the pilot can do anything about, of course, and the Shuttle must then be returned for a complete check over.

CRT DISPLAY SYSTEM



The MCDS on the Orbiter crew compartment flight deck allows onboard monitoring of Orbiter systems, computer software processing and manual control for flight crew data and software manipulation. The system is composed of three types of hardware: display electronic units [DEUs], display units that include the CRTs, and keyboard units, which together communicate with the GPCs over the display/

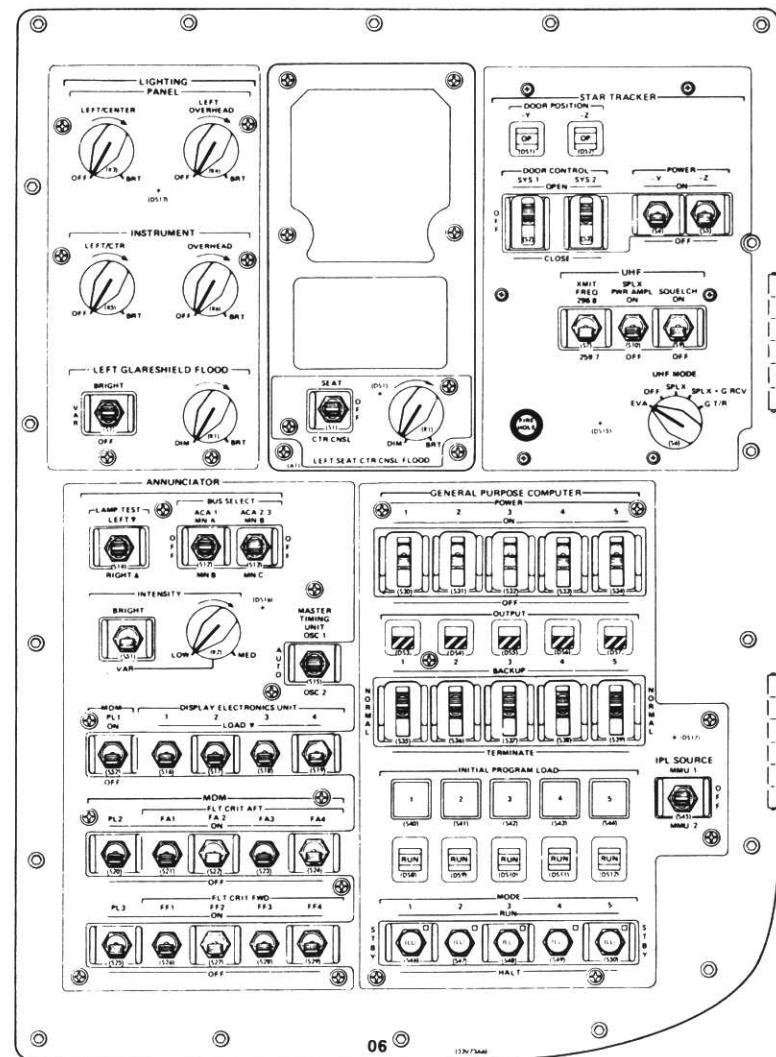
keyboard data bus network [see GPCs, below]. The MCDS provides almost immediate response to flight crew enquiries through displays, graphs, trajectory plots and predictions about flight progress. The crew controls the vehicle system operation through the use of keyboards in conjunction with the display units.

Three keyboards are located on the flight deck: two on the left and right sides of the flight deck center console [PANEL C2] and one on the flight deck at the side aft flight station [PANEL R12]. Depending on crew requirements and preferences, each of the front keyboards can communicate with any of the front DEUs: the aft keyboard, however, is only wired to display on the aft DEU.

PROBLEMS

If the CRTs go, there is little the crew can do about it. The likelihood of all of them going at once is extremely remote, however. The only thing the crew can do is to replace a blown CRT with one of the others - i.e., if one of the front CRTs went, the crew could replace it with the aft one. This simulator is not, for obvious reasons, able to recreate this emergency.

GENERAL PURPOSE COMPUTERS [GPCs]



Almost all of the operations carried out by the Space Shuttle are controlled or overseen by the main computer system. The DPS [Data Processing System] consists of five General Purpose Computers [GPCs] connected to the many hundreds of feedback sensors and actuators throughout the Shuttle. These are each made up of a

central processing unit [CPU] and an input/output processor [IOP], and each of the five do a different job. All five are IBM AP-101 computers, and contain a memory area for storing data and software. They are collectively referred to as the Shuttle's Main Memory, into which are loaded all the flight and operational information systems.

The system software [or Executive] controls the computer systems and monitors communication between them. It also supports the user interface modules to provide interaction with the crew.

The applications software consists of specific modules to manage navigation and control, etc., at various stages of the mission. Each major module of operations or OPS has a number associated with it:

- OPS 1 Ascent
- OPS 2 On Orbit
- OPS 3 Reentry
- OPS 4 Orbit operations
- OPS 6 RTLS [loaded along with OPS 1]
- OPS 8 On Orbit Checkout
- OPS 9 Computer Utilities

Each major OPS also has a particular CRT display associated with it.

GPC POWER ON/OFF [PANEL O6] - First of all you have to turn the things on. These switches are guarded, as, for one, they control 600 watts of power each, and moreover the GPCs should not be able to be turned off inadvertently.

GPC OUTPUT [PANEL O6] - has three positions: BACKUP, NORMAL & TERMINATE. BACKUP is only used for the GPC containing the BFS, which stops it being used until needed; All switches for operating GPCs will be set at NORMAL, whereas the GPCs controlling systems management [i.e., on-orbit operations] will be positioned at TERMINATE, as they shouldn't be commanding anything during the flight phases.

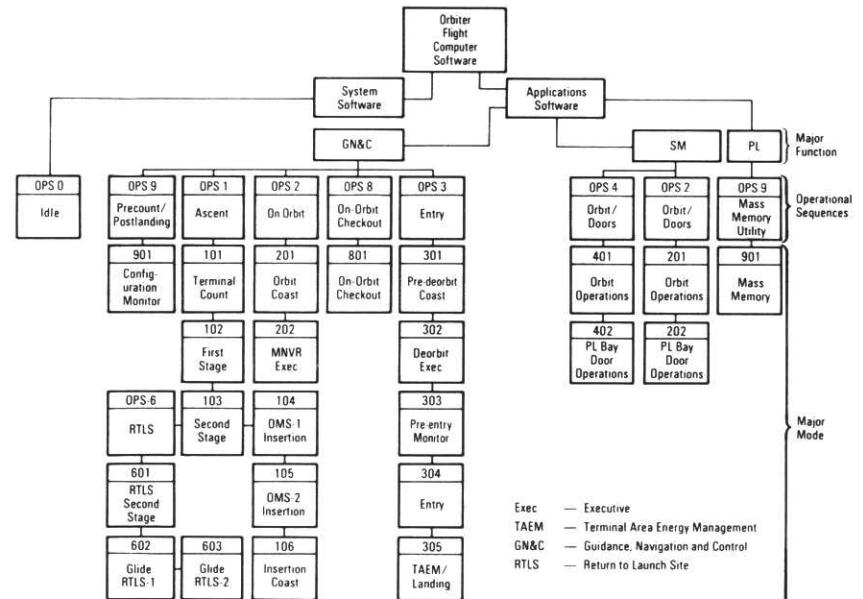
MODE [PANEL O6] - three positions: RUN, STBY & HALT. Normally if these switches are put into HALT in the RUN position, the software is precluded from operating. However, if the switches are put into STBY, the software can still not be executed, but the GPC is in a software controlled state. Normal practice is to go from HALT to STBY and then to RUN, and vice versa, as this gives the software a chance to ready and clean itself up.

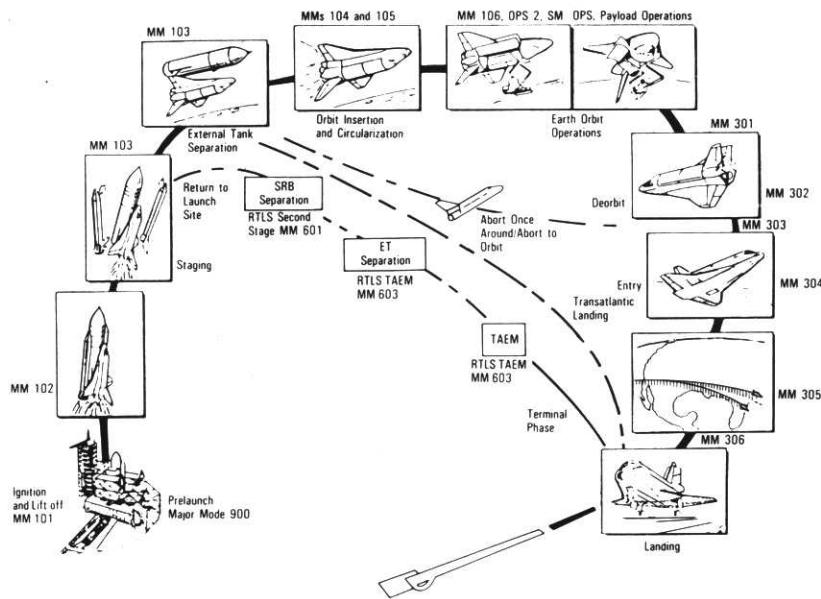
ORBITER FLIGHT COMPUTER SOFTWARE - refers to all the various software commands that are typed in at the relevant moment by the flight crew.

PROBLEMS

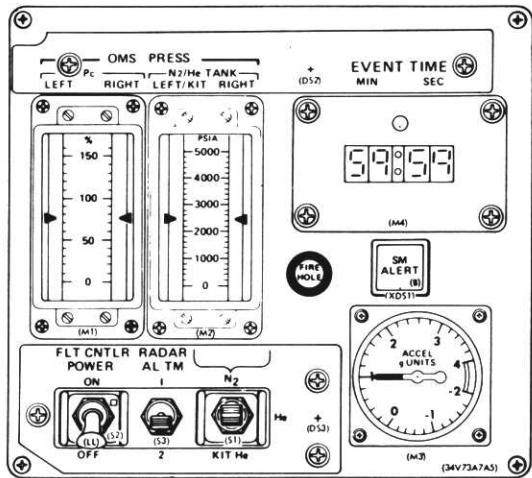
If the main GPC fails, the Shuttle has its own backup flight system, or BFS, which is loaded into the GPCs and the mass memory unit. As it's only concerned with the emergency ascent, insertion into orbit or de-orbit of the Shuttle, it has a great deal less information stored within it. Thus, it takes up only one of the GPCs, (ordinarily No.5), although any of the GPCs could become a BFS if necessary. Remember, GPC 5 must be switched on at the pre-launch phase, otherwise the Shuttle won't take off.

Other than this, however, for the purposes of SPACE SHUTTLE - THE SIMULATOR, the BFS won't be operable.





ORBITAL MANEUVERING SYSTEM



might be needed at the orbit's apogee [furthest point] to make it more circular. This is called OMS-2. If only one OMS burn is used, this is known as 'Direct Insertion' [into orbit].

The Orbital Maneuvering System [OMS] is housed in two pods, one on each side of the aft fuselage. The OMS contains 23,878 pounds of propellant and is able to deliver 6000 pounds thrust from nozzles which can be gimballed by up to 6 degrees. The OMS is first used just after Main Engine Cut Off [MECO] and External Tank [ET] separation to boost the Shuttle into an elliptical Orbit. This is called OMS-1. Dependent on the mission, a second burn

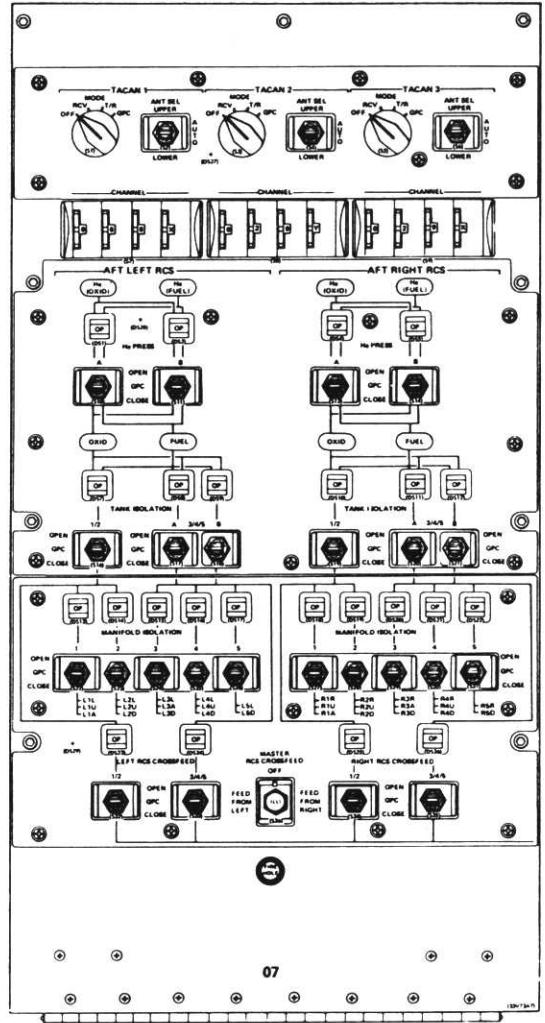
The pods also house the aft Reaction Control System [RCS]. There is also a forward Reaction Control System in the nose of the craft in front of the Crew Compartment. All together, the RCS comprises 38 primary thrusters each delivering 870 pounds thrust and six vernier engines for fine adjustments, each delivering 24 pounds.

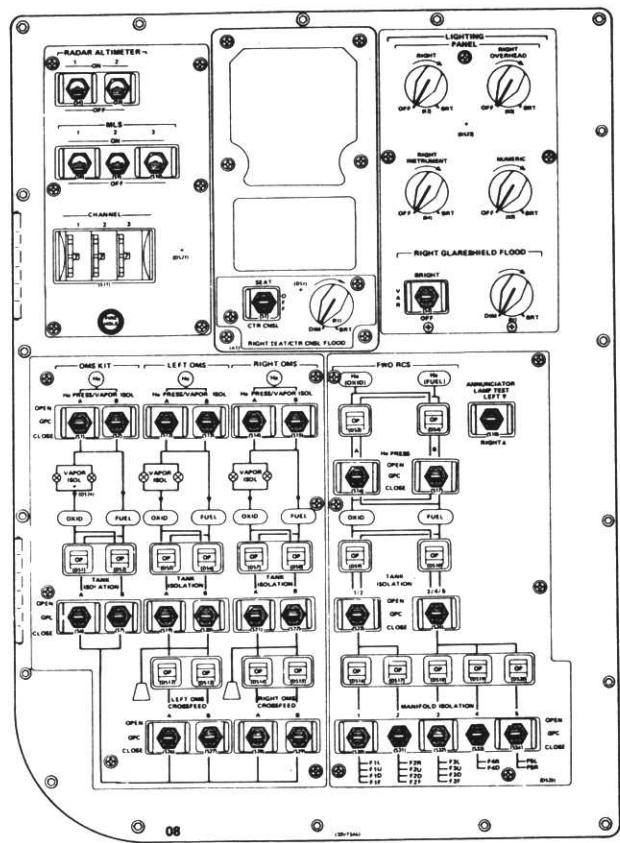
The RCS is used just after ET separation to maneuver the Orbiter clear of the tank. The RCS is also used throughout the flight to adjust the Pitch, Roll and Yaw of the space craft, and to counter movements outside the range of the OMS gimbaling system.

The OMS is used in re-entry until the air pressure is such that the elevons and rudder can take over.

The hydrogen and oxygen propellants are helium pressurized through the propellant management system. The propellant management system is complex and usually controlled by computer. In contingency situations, the crew can carry out many operations using manual switches.

The RCS is normally controlled by the Digital AutoPilot [DAP] or manually using the Rotational Hand Controller [RHC] or the Translational Hand Controller [THC] via the GPCs.





The propellant management system is complex and normally computer controlled, as long as the switches on PANEL O8 are set to GPC. All that the pilot will normally be concerned with are the propellant and pressurization system pressures, which are shown on the OMS PRESS gauges on PANEL F7, and the fuel levels, shown on the RCS/OMS PRESS gauges on PANEL O3.

For full breakdown of the operation of the OMS engines, see the OMS BURN sequences under

LAUNCH SEQUENCE within the MISSION PROFILES section at the end of the manual.

FURTHER REFERENCE

See also MAIN PROPULSION SYSTEM & AUXILIARY POWER UNITS.

LIFE SUPPORT SYSTEM

The Crew compartment is pressurized to 14.7 psi by an 80/20 Nitrogen/Oxygen air mix. The system has two separate Oxygen Supplies, two Nitrogen Supplies plus an emergency Oxygen Supply.

The Air supplies are controlled by switches on PANEL L2. The cabin pressure and flow rates are shown on gauges on PANEL O1. If the cabin pressure falls [or rises] too far, or if an increased Nitrogen or Oxygen flow is detected [indicating a possible leak], the master alarms go off, the CABIN ATM light on PANEL F7 illuminates and a klaxon sounds in the crew cabin.

The cabin VENT switches on PANEL L2 are used to vent the cabin to equalize the internal pressure with the external pressure. To do so, set VENT ISOL to CLOSE and VENT to OPEN.

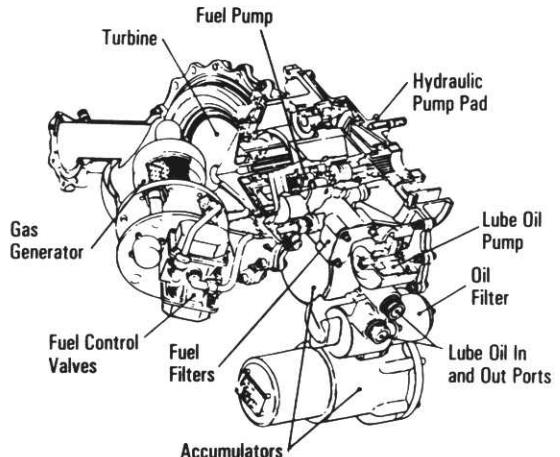
During the countdown [T-1hr 30 mins] the crew compartment is pressurized to about 16.7 psi to check for leaks.

FURTHER REFERENCE

See EMERGENCY EGRESS.

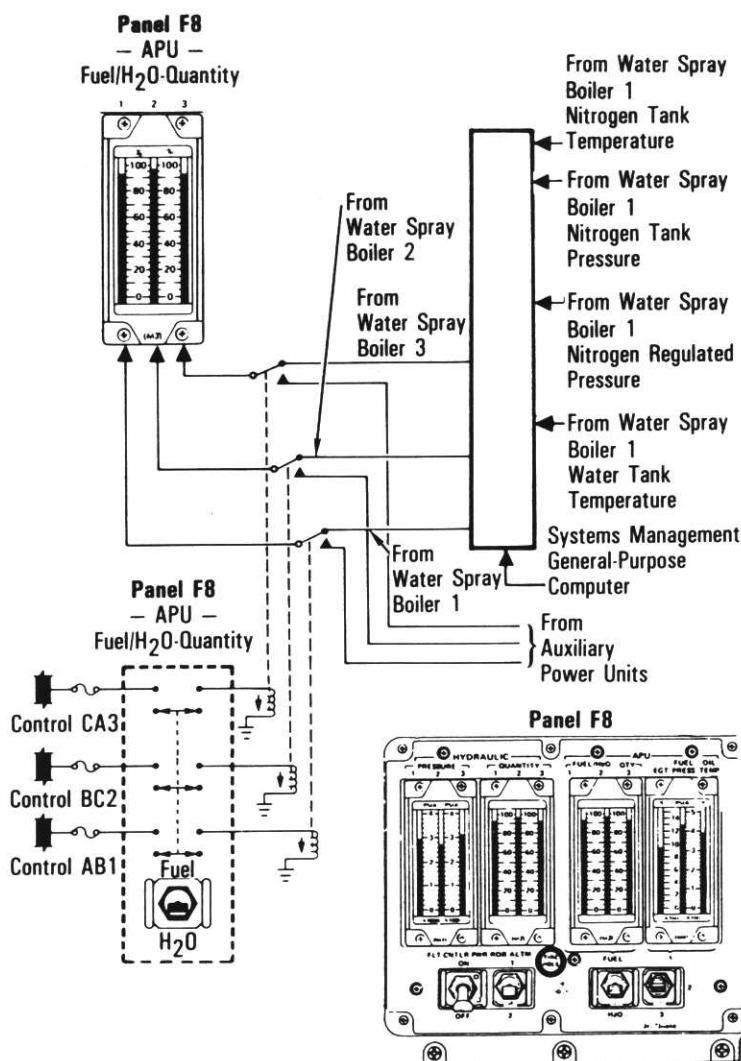
AUXILIARY POWER UNITS

The Auxiliary Power Unit is a hydrazine-fuelled, turbine-driven power unit that generates mechanical shaft power to drive a hydraulic pump that produces pressure for the Orbiter's hydraulic system. There are three Auxiliary Power Units [APUs], for the three hydraulic systems, all housed in the aft fuselage, providing the hydraulic power to control engine gimbal actuators, propellant management control valves, elevons, rudder, landing and steering gear.



Dimensions: 20 Inches Wide, 21.80 Inches Long,
18 Inches Deep

The APUs are readied at about T-six minutes and started about five minutes before launch and remain active until after the first OMS burn. They are not operated after this first OMS thrusting period because hydraulic power is no longer required. One of the units is re-activated again about a day before de-orbit to support checkout of the Orbiter flight control system - elevons, rudder/speed brake, body flap, and all other Orbiter aerosurfaces.

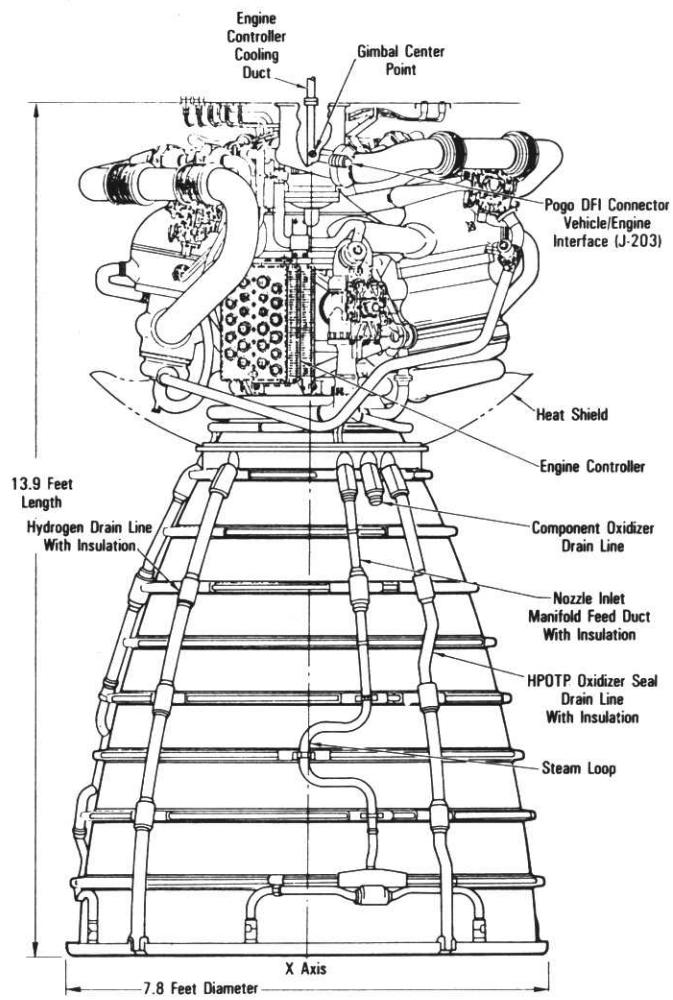


Each APU has its own controller. Before starting up the APUs, all the boiler, hydraulics and fuel valves and switches have to be set to their correct positions. Once this has all been done, the APUs can then be started up. To do so, first set the APU CNTRL PWR switches to ON on PANEL R2. When the APUs are ready to start, the READY TO START indicators signal gray. Now start the APUs by switching the APU OPERATE switches to START/RUN. For full details of APU start-up, see MISSION PROFILES at the end of this manual.

The APUs can be run at three speeds: low, normal and high. These can be set using the APU SPEED SELECT switches. When the APU AUTO SHUTDOWN switches are at ENABLE, the controllers will automatically shutdown the APUs if an overspeed [>92880 rpm] or underspeed [<57600 rpm] condition occurs, lighting the appropriate light on PANEL F7. Loss of an APU will cause the corresponding hydraulic systems to become inoperative lighting the HYD PRESS light on PANEL F7.

The APUs can be run in contingency situations outside their tolerances by setting the AUTO SHUTDOWN to INHIBIT [PANEL R2] and setting the APU OPERATE switches to START ORIDE/RUN. If the APU oil temperature exceeds 290F the APU TEMP light appears on PANEL F7. The general APU status can be monitored on the gauges on PANEL F8.

MAIN PROPULSION SYSTEM



The Main Propulsion System [MPS] consists of the three main engines [SSMEs], the External Tank [ET] and a propellant management system. The SSMEs can be gimballed up to 10.5 degrees under the control of hydraulic actuators.

During the launch phase, the MPS is also assisted by the two Solid Rocket Boosters, or SRBs [see below].

The SSMEs can be controlled from 65% to 100% of their rated power level [100% represents 375,000 pounds thrust at launch] by use of the SPEED BRAKE/THROTTLE. The engines are controlled by their own individual computers [called controllers] receiving commands from the main Shuttle General Purpose Computers [GPCs].

Controllers and support circuits are enabled by the switches on PANEL R2.

The hydrogen and oxygen propellants are helium pressurized through the propellant management system. The propellant management system is complex and usually controlled by computer, the control switches being set to GPC. In emergency situations, usually aborts, the crew can carry out many operations using manual switches on PANEL R2. The propellant management system pressures are shown on gauges on PANEL F7.

The Orbiter has three hydraulic systems for providing thrust vector control and actuating engine valves. The main distribution valves are controlled by the HYDRAULICS MPS/TVC 1, 2 and 3 switches on PANEL R4. The talkback indicators show OP or CL accordingly.

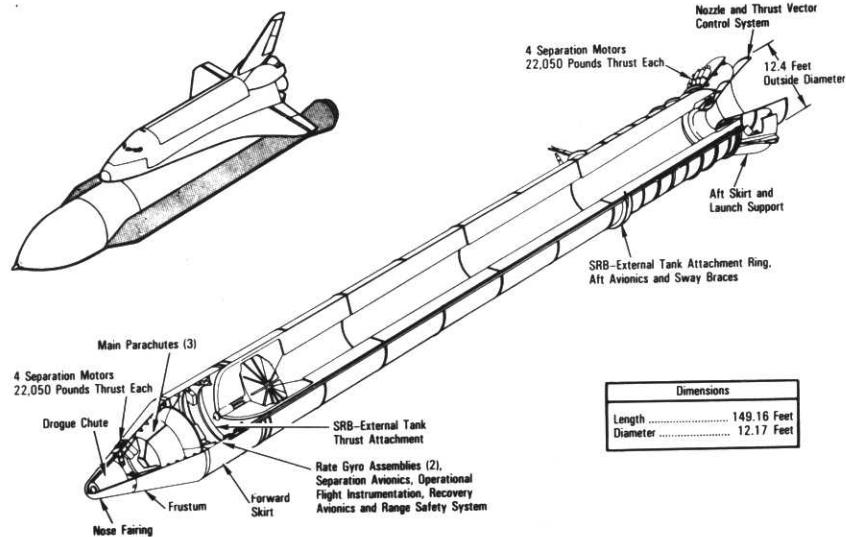
In emergencies, [and after GPC control has failed] fuel can be dumped by setting the MPS PRPLT DUMP switch on PANEL R2 to SEQUENCE START.

The HYDRAULIC MPS/TVC ISOL valve switches on PANEL R4 are closed on-orbit to protect against hydraulic leaks.

FURTHER REFERENCE

For controls required for pressurization system, see appropriate section of MISSION PROFILES.

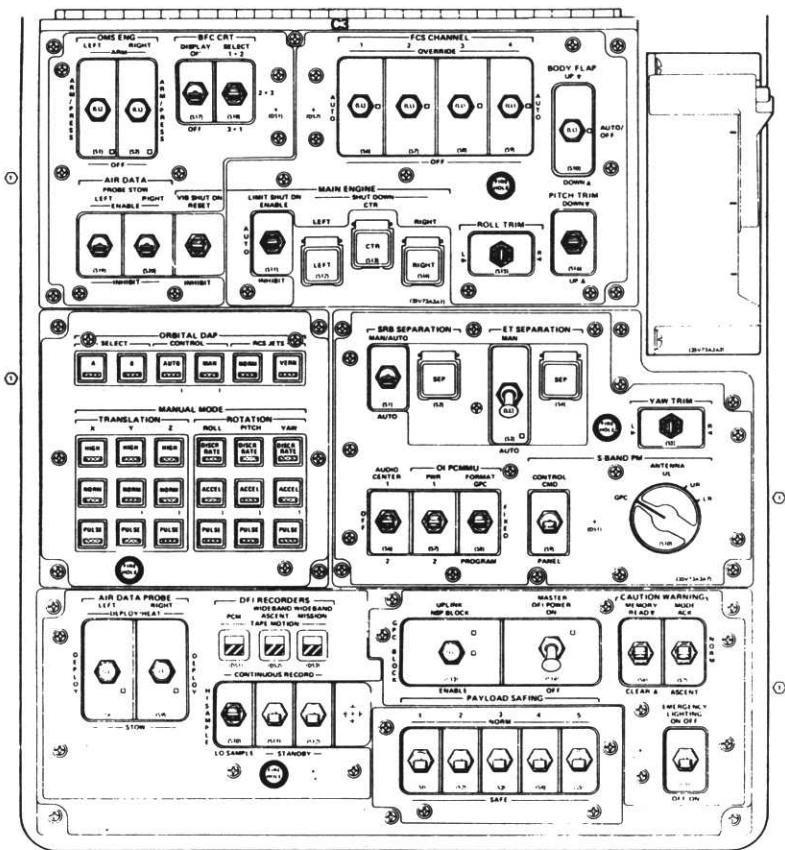
SOLID ROCKET BOOSTERS [SRBs]



The two Solid Rocket Boosters [SRBs] are attached on each side of the External Tank [ET]. They are each 149.16 feet long and 12.17 feet in diameter and way about 1,300,000 pounds at launch, including their load of about 1,100,000 pounds propellant. Each SRB develops approximately 3,300,000 pounds thrust at launch, providing nearly three quarters of the Shuttle's initial thrust. The precise direction of thrust can be adjusted by gimballing the rocket nozzle using actuators powered by two Hydraulic Power Units [HPUs].

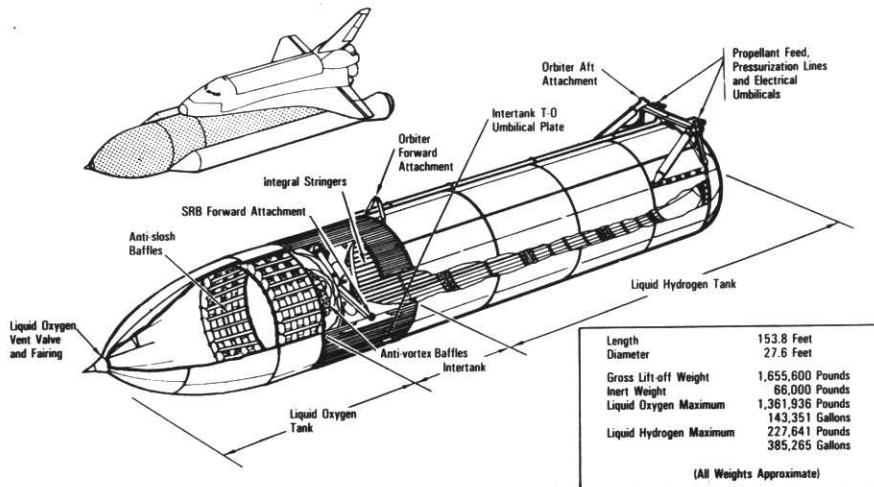
SRB ignition takes place at a fraction of a second before launch after the successful starting of the main engines.

About 2 minutes after launch, 4 separation motors fire to separate the SRBs from the ET. The SRBs continue to rise after separation to nearly 220,000 feet before falling to around 15,700 feet when parachutes are deployed. The SRBs are recovered from the Ocean approximately 122 nautical miles from the launch site.



Separation is controlled by the SRB SEPARATION AUTO/MAN switch on PANEL C3 and the SEP push button. In the AUTO position the GPCs do the separation. To manually jettison the SRBs, select MAN and press the SEP button.

EXTERNAL TANK



The External Tank [ET] contains the liquid hydrogen and liquid oxygen propellant to fuel the main engines during ascent. The ET is 153.8 feet long and 27.6 feet in diameter and weighs around 1,655,600 pounds at launch including about 1,589,600 propellant.

The connections go from ET to Orbiter through the ET umbilical disconnect cavities, areas of the Orbiter's surface that house all the fuel lines and mechanical disconnect systems that maintain the ET/Orbiter connections.

The ET is jettisoned immediately after Main Engine CutOff [MECO] and breaks up in the upper atmosphere before falling into the ocean. It is separated from the Orbiter at three structural attach points, separation occurring before orbit insertion, normally under automatic control.

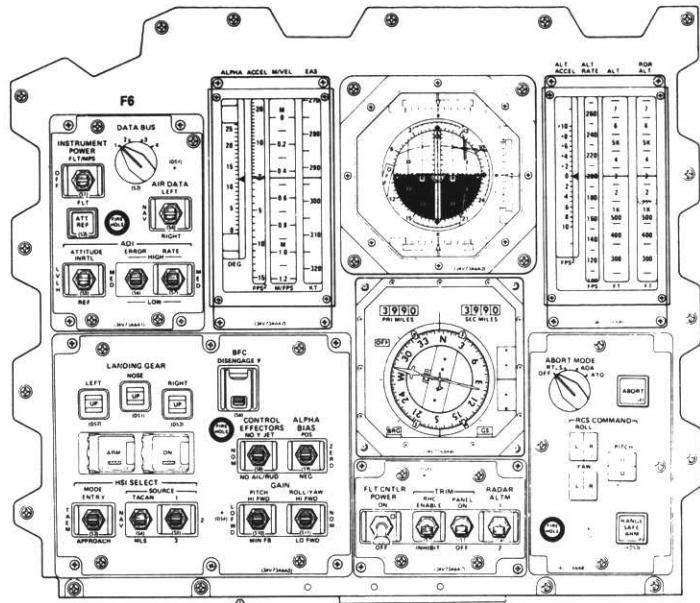
Separation is controlled by the ET SEPARATION AUTO/MAN switch on PANEL C3 and the SEP push button. In the AUTO position the GPCs do the separation. To manually jettison the ET, select MAN and press the SEP button.

NOTE

The ET Umbilical Doors must be closed after ET SEP. This is normally done automatically by GPC. Optionally, or in contingency conditions, this can be done by the crew: this is done by ensuring that the ET UMBILICAL DOOR CENTERLINE LATCH switch on PANEL R2 is in the STOW position, setting the ET UMBILICAL DOOR LEFT & RIGHT LATCH switches to RELEASE [takes about 6 seconds to unlatch] and setting the ET UMBILICAL DOOR LEFT & RIGHT DOOR OPEN/OFF/CLOSE switches to CLOSE [takes about 24 seconds]. The latch talkback indicators show LAT or REL and the door indicators show OP or CL, both showing BARBERPOLE when the doors/latches are in transit.

The umbilical doors are normally closed automatically in RTLS aborts [default position is GPC].

GUIDANCE, NAVIGATION AND CONTROL



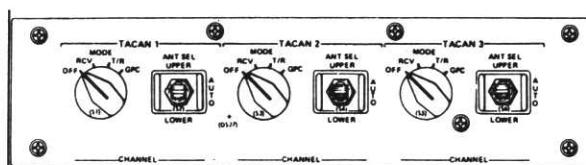
Guidance, Navigation and Control [GNC, or sometimes GN&C] of the Space Shuttle is carried out with the support of the four main GPCs or the BFS in contingency situations. GNC has two operating modes: **Automatic** mode in which the GPCs effectively fly the computer with the flight crew selecting the operating sequences via the computer

keypads; and **Manual** mode, in which the crew flies the Orbiter using the Rotational Controller, translational controller, thrust controller and rudder pedals, etc.

The Orbiter has several navigation aids which help compute its position. There are three Inertial Measurement Units [IMUs] which measure changes in the Orbiter's attitude and velocity. The IMUs are normally powered up and in operation by the time the crew enter the Orbiter before launch. The IMUs drift with time and are regularly recalibrated using the Star Trackers which can fix the Orbiter's position by angular comparisons to known reference stars. In addition, the star trackers can be used to give angular information from the Orbiter to a target in orbit. The Crewman Optical Alignment sight is a backup to the Star Trackers.

Information from the IMUs is used to feed the Acceleration and rate indicators on PANELS F6 and F8.

TACAN



Approach and landing systems use the ground-based Tactical Air Navigation system [TACAN], used the world over by

commercial and military aircraft. This system feeds track information to the direction indicators on PANEL F8 and F6, and is activated by the OPS programs fed into the computer by the crew through the keypad on PANEL C2 when on GPC. The space Shuttle uses three TACAN systems for the sake of redundancy, i.e., in case one or more breaks down. TACAN's maximum range is 400 Nautical Miles [460 Statutory Miles].

With so much computer hardware and software at their disposal, it's rare for the flight crew of the space Shuttle to ever need to touch any manual guidance controls, as the Shuttle can launch, orbit, re-enter and land entirely under computer control. Regardless, many of the Shuttle flight crews have still chosen to guide the Orbiter by hand, most often when landing, at which time the guidance computers and displays act much as traditional navigation aids to the Pilot or Commander.

In contingency, navigation systems can be switched on manually using the HSI SELECT switches on PANELS F6 & F8.

TACAN - MANUAL PROCEDURE:

TACAN 1, 2 or 3 ANT SEL to AUTO [PANEL 07]
 TACAN MODE to GPC [PANEL 07]
 HSI SELECT - SOURCE to TACAN [PANEL F6/8]
 HSI SELECT - MODE to TAEM [PANEL F6/8]

When the Orbiter has turned onto its final leg for landing, it can be guided by a Microwave Scan beam Landing System [MSBLS]. This system feeds the track and glideslope indicators on PANELS F6 and F8. The Orbiter also has two radar altimeters on board which feed information to the Altitude indicator on PANELS F6 and F8.

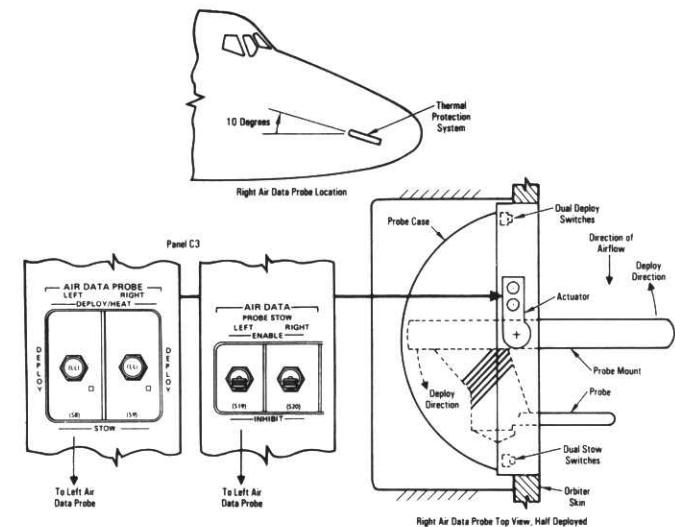
FURTHER REFERENCE

For further details of landing procedures, see also MISSION PROCEDURES, RE-ENTRY [MM304] onwards.

2. INSTRUMENTS

The main Guidance and Navigation instruments, detailed below, are all located on the Commander's and Pilot's main PANELS [F6 and F8]. The Commander and Pilot also each have a Head Up Display [HUD]

AIR DATA SYSTEM



The air data system provides information on the movement and position of the Orbiter in relation to the air masses around it, and relates this information to the AMIs, the AVVIs and the CRTs. For information on these displays, see the relevant sections.

This data is collected by the AIR DATA PROBES, positioned on the left and right of the Orbiter's nose section. The **AIR DATA PROBES** are deployed only during the final descent stages when the Orbiter's velocity drops below Mach 3.

Each probe is independently deployed by two AC motors, and is controlled by its AIR DATA PROBE SWITCH [PANEL C3]. To deploy the probes, the LEFT & RIGHT SWITCHES are positioned to DEPLOY. If the Air Data Probe Heaters are required, the switch is set to DEPLOY/HEAT. When the probe is deployed, taking 15 seconds with both motors, 30 with one.

To stow the heaters, normally only done when the Orbiter is on the ground, the AIR DATA PROBE STOW LEFT & RIGHT SWITCHES [PANEL C3] are switched to ENABLE, then the AIR DATA PROBE SWITCHES are switched to STOW, stowing the probes. If the AIR DATA PROBE STOW switch is set at INHIBIT, the probes cannot be stowed as the AC motor circuits are disabled, thus saving the microswitches.

PROBLEMS

The only problem comes when neither of the probes work - this means that none of the descent-related switches mentioned above, and detailed below, will work either, showing a red flag across them. If this occurs, which it has never done so far, then the pilot has no choice but to guide the Orbiter into land as best he can.

RADAR ALTIMETER

The Space Shuttle's two radar altimeters measure the absolute distance from the Orbiter to the ground, and enable the instruments to show not only the ground immediately below, but any features, cliffs, mountains etc., to the front or aft, or to either side of the craft. The two systems can operate independently of each other, but if they are used together, they present to the instruments an averaged reading of the terrain below.

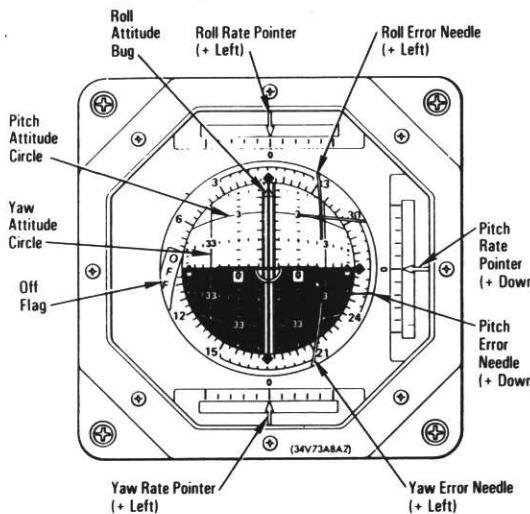
This facility is available at any altitude from zero to 5000 ft., but has a tendency not to work if the Orbiter is pitching or rolling to greatly.

The Radar Altimeter can be accessed by either the commander or the pilot, for display on their respective AVVI. The commander uses RADAR ALTM 1/2 SWITCH [PANEL F7], and the pilot's being on PANEL F8. However, before the altimeter can be used, the power to the switches must first be switched on, using the RADAR ALTIMETER ON/OFF 1/2 SWITCH [PANEL 08].

PROBLEMS

The Radar Altimeter gauge will show a red off flag if there is a loss of power, loss of lock, bad data or three communications faults. In this case, the Radar Altimeter won't work, and the crew have to rely upon their remaining instruments, and in a worst case scenario, on their judgement.

ATTITUDE DIRECTION INDICATOR

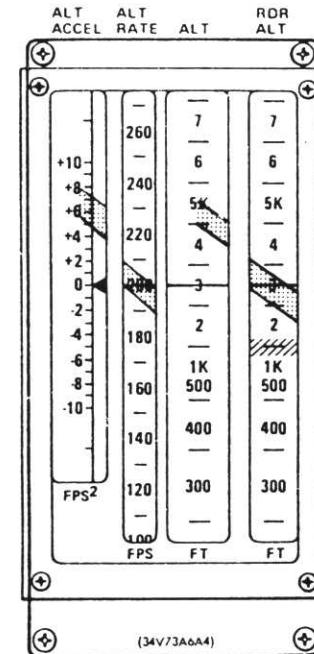


The Attitude Direction Indicators [ADIs], the uppermost of the two indicators on PANELS F6 & F8, are active throughout the mission. There is an Aft ADI on PANEL A1 active during the orbit phase. The instrument is similar to the artificial horizon found in a conventional aircraft, and shows the Orbiter's attitude.

HORIZONTAL SITUATION INDICATOR

The Horizontal Situation Indicators [HSIs], beneath the ADIs, are active during re-entry and landing [and RTLS]. The HSIs show the Orbiter's direction and position relative to the required track and glideslope.

ALTITUDE AND VERTICAL VELOCITY INDICATOR



The Altitude and Vertical Velocity Indicators [AVVIs - PANELS F6/8] show the vertical acceleration [ALT ACCEL], the vertical velocity [ALT RATE], the altitude as given by a barometric altimeter [ALT], and the altitude as given by a radar altimeter [RDR ALT].

PROBLEMS

An RA OFF FLAG comes across the RDR ALT gauge under certain circumstances:

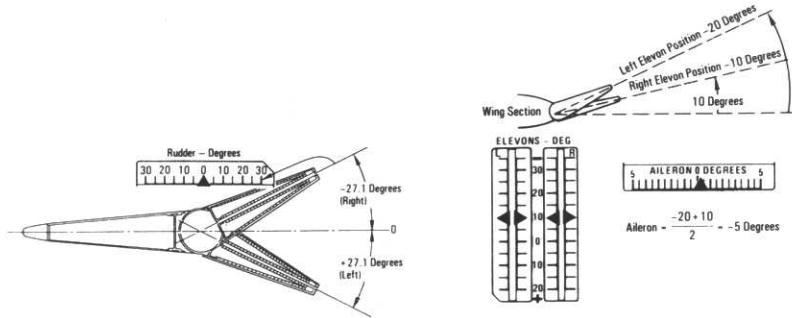
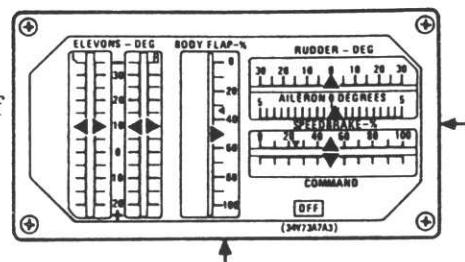
- 1] RA ON/OFF switch on PANEL O8 is turned off;
- 2] loss of power due to too much pitch and/or roll
- 3] loss of power due to bad data

To rectify, correct whichever contingency has gone wrong.

The source of information for the AMI is either from the navigation software or from left or right Air Data Probes, as determined by the setting of the AIR DATA switches on PANEL F6. The two units are driven independently, but can have the same information displayed on both, or not, as the case may be.

SURFACE POSITION INDICATORS

The Surface Position Indicators [SPIs - PANEL F7], active during entry [and RTLS], show the actual and commanded settings of the Orbiter air surfaces: rudder, aileron, elevons, and body flaps.

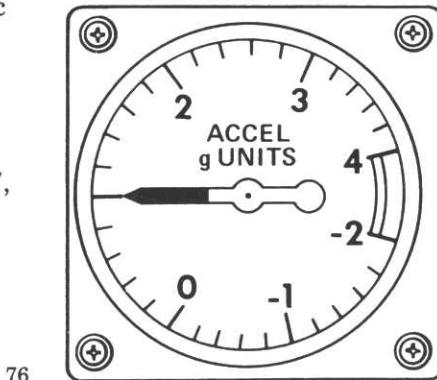


RCS COMMAND LIGHTS

These indicators [PANEL F6], active during entry and RTLS, illuminate to show when the RCS jets for pitch, roll and yaw are being used or when the air surfaces are imparting similar effects to the Orbiter. Once the respective dynamic pressures are achieved [10 psf for Roll jets, 20 for Pitch: yaw lights continue to function until Mach 1], the lights are not used again until dynamic pressure reaches 50 psf. At this point, both Pitch and Roll lights assume a new function, illuminating whenever the elevon surface drive rate exceeds 20 degrees per second [or 10 if only one hydraulic system is left].

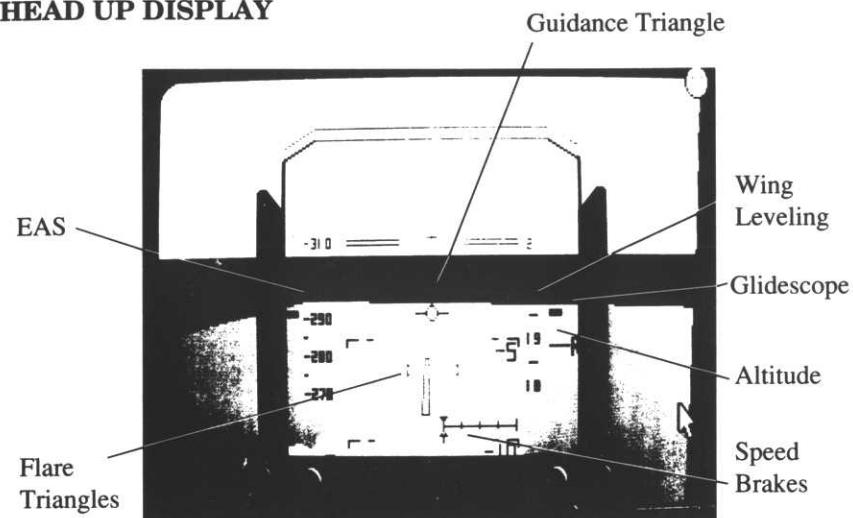
G FORCE METER

This gauge, located on PANEL F7, shows the G forces acting on the Shuttle and crew.



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HEAD UP DISPLAY



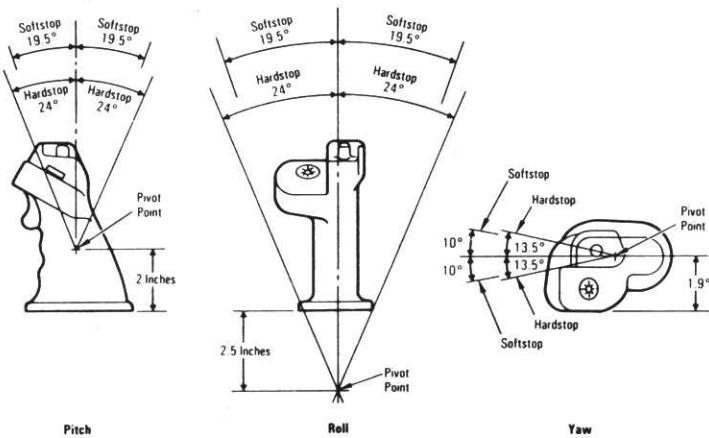
The Heads Up Displays [HUDs] work in a similar way to those on modern jet planes, conveying crucial instrument readings to the Pilot so that he doesn't have to look down at the instrument panels during the final approach.

DIGITAL AUTO-PILOT

The Shuttle is normally controlled almost entirely by the four main GPCs from a combination of pre-programmed sequences. Some of these sequences are activated automatically, while some are controlled by the crew via the keypads. The heart of the flight control software is the DIGITAL AUTOPILOT [DAP]. During the ascent phase [OPS 1] The DAP will normally control engine throttle and vector transitions, SRB and ET separation, MECO and orbit insertion. RTLS control [OPS 6] is available as an overlay to OPS 1 as there would not be enough time to load OPS 6 separately. During the main mission [orbit] phase [OPS 2], the DAP controls the RCS engines as required to maintain orbit regularity and Shuttle attitude and to adjust the orbit to rendezvous with targets. During the Re-entry phase [OPS 3], the DAP controls the de-orbit burn, re-entry attitude and speed control, and landing.

By switching on the ORBITAL DAP MAN switch on PANEL C3, the Commander and Pilot can override the DAP if they wish to have manual control or in a contingency situation. Note that the Orbiter is "fly by wire" so even when under manual control, the manual commands are still processed by the computer.

ROTATIONAL HAND CONTROLLERS



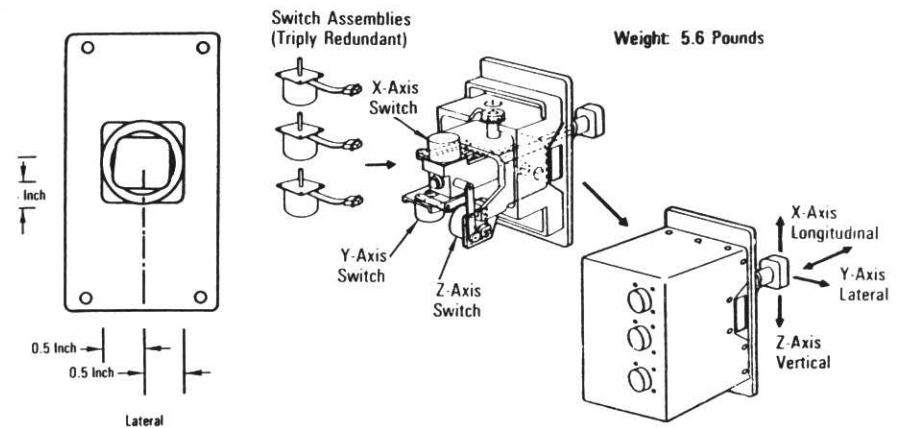
There are three Rotational Hand Controllers [RHCs], one each at the Commander's and Pilot's stations, and one at the aft station. The action of the controllers depends on the phase of the mission. During the ascent stage, the RHCs gimbal the SSMEs and SRB engines. For orbit insertion and de-orbit, they gimbal the OMS engines and control thrusting of the RCS engines. While in orbit they control the RCS engine thrusting. During the first part of re-entry they control RCS thrusting and, later on, the elevon positions. During orbit, the control is 3 axis [pitch, roll and yaw]. During ascent, re-entry and landing the control is only 2 axis [pitch and roll].

RHC/PANEL ENABLE/INHIBIT

In order to be able to manually control the movements of the Shuttle while under nominal GPC control, the crew must first switch on their RHCs.

Switch the RHC/PANEL switch from INHIBIT, wherein no RHC commands will effect the Shuttle, to ENABLE, where they will. Both the commander and pilot can enable their RHCs, and as a failsafe, if they pull in opposite directions, any such contrary instructions will cancel each other out.

TRANSLATIONAL HAND CONTROLLERS



There are two Translational Hand Controllers [THCs]. One is at the Commander's station and the other is at the aft station. The Commander's THC is active during orbit insertion, orbit and de-orbit. The aft THC is only active during orbit. The THCs are used to control the RCS engines [this is independent of the push button controls on PANELS C3 and A6].

RUDDER PEDALS

The Commander and Pilot have aircraft-style rudder pedals which control the Orbiter in the Yaw axis during flight within the atmosphere. Furthermore, the pedals also operate the nose wheel steering, while depressing the top of the pedals provides braking to both the main and the nose wheels.

THRUST AND BRAKING

The Commander and Pilot each have speed brake and thrust controllers which allow them to control thrust during the ascent stage [by varying the thrust from the main engines] and airspeed during landing [by opening and closing the tail speed brake].

BODY FLAP

There are two body flap switches, one for the commander on PANEL L2, and one for the pilot on PANEL C3. The switches allow the crew to move the body flaps manually either for SSME thermal protection or reducing elevon deflections during entry phase. Each switch is spring-loaded to return to the center position, and the other positions are momentary ones. For example, the crew have to hold the switch in position to move the body flaps up or down.

To release the switch from automatic, simply move it to either UP or DOWN positions: while in manual, the white light at the bottom of the BODY FLAP MAN/AUTO switch on PANEL F2/4 will be illuminated. To return it to auto, press this BODY FLAP switch and the auto light will illuminate.

2. ON-ORBIT MANEUVERS

All of the major GNC tasks are carried out once in orbit under the OPS 2 software. This is subdivided into the “orbit coast”, MM201, in which the majority of orbital tasks are carried out including attitude adjustments, and the “maneuver/execute” in which OMS translations are made.

Before de-orbit, OPS 8 [MM801] can be used to checkout all systems, including the gimbaling of engine nozzles, movement of aero surfaces, checking of valves and hydraulic systems, and instrumentation.

ORBITER

The Space Shuttle Orbiters, of which there have been 5 [Enterprise, Columbia, Challenger, Atlantis and Discovery] have a typical length of 122.2 feet and wingspan of 78.06 feet.

The pressurized crew compartment is in the forward fuselage just behind forward Reaction Control System [RCS]. The main body of the Orbiter is taken up by the payload bay, which is 60 feet long.

The rear of the Orbiter houses the Space Shuttle Main Engines [SSMEs], and the Orbital Maneuvering System [OMS], as well as the aft RCS pods.

The Orbiter structure is built mainly of aluminium alloy covered with the now-legendary re-usable insulation tiles.

FURTHER REFERENCE

For more details, see individual sections.

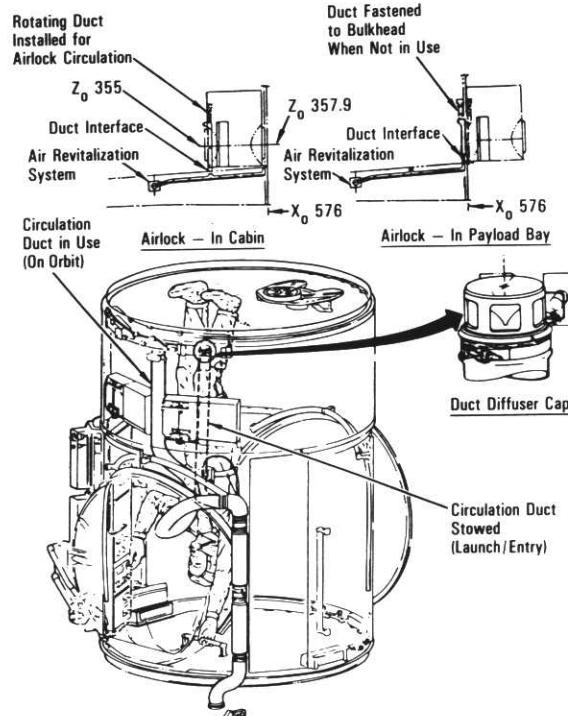
CREW COMPARTMENT

The Crew compartment is a sealed pressure-tight three level cabin of about 2325 cubic feet. It is mounted inside the forward fuselage at the front of the Orbiter. Entry to the Orbiter is through the side hatch to the mid deck, or the airlock to the payload bay. The side hatch can be jettisoned in emergencies.

The compartment would normally accommodate four crew members on the flight deck and up to four on the mid-deck. A further two crew members could be carried in emergency conditions. The lower tier of the compartment serves as an equipment bay.

The flight deck contains all of the craft's flight and payload controls and instrumentation.

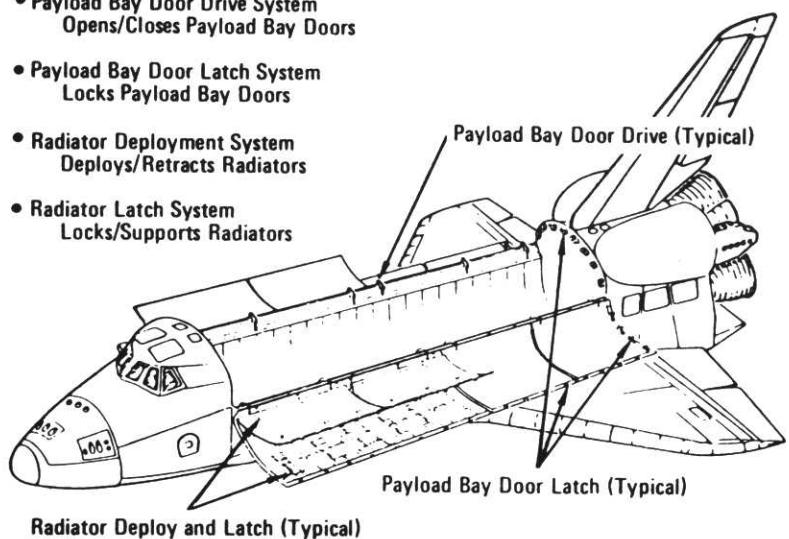
AIRLOCK



The Airlock is located in the mid-deck of the crew compartment leading to the payload bay. It will accommodate two astronauts suited in Extra-vehicular Mobility Units [EMUs]. Airlock pressurization can be controlled from the mid-deck or from inside the airlock itself. EMUs provide life support for up to 7 hours with a thirty minute emergency backup.

PAYOUT BAY

- Payload Bay Door Drive System Opens/Closes Payload Bay Doors
- Payload Bay Door Latch System Locks Payload Bay Doors
- Radiator Deployment System Deploys/Retracts Radiators
- Radiator Latch System Locks/Supports Radiators

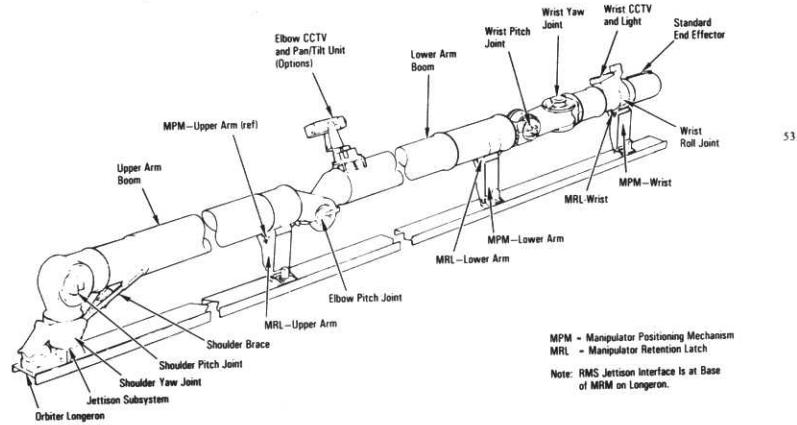


The Payload Bay is approximately 60 feet long. The doors provide a fairly airtight seal and protection to payloads during ascent and return. Once in orbit, the payload bay doors are opened to allow the environmental control radiators to be deployed to disperse heat.

Normally, the control sequence for opening and closing the payload bay door bulkhead latches, centerline latches and payload bay doors is through the Orbiter's keypad, using pre-determined programs to open and/or close the doors in sequence.

In a contingency, however, they can be opened and closed by individual commands on the keypad: for full list of keypad activities, see **GPC**, above.

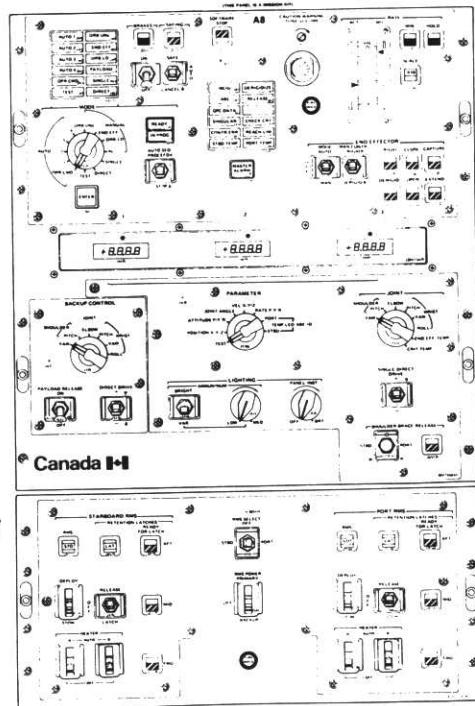
REMOTE MANIPULATOR SYSTEM



The Remote Manipulator System [RMS] main component is the manipulator arm which can either maneuver a payload from the payload bay for deployment, or capture and retrieve a free-flying object: not all payloads need the RMS for deployment or retrieval, however.

The manipulator arm is installed on left side of the payload bay and is connected to a control panel and rotational and translational controllers at the flight deck aft station. Normally, the arm is controlled by one crew member looking through the aft windows assisted by a second crew member controlling the closed circuit monitors.

The manipulator arm is 50.25 feet long and 15 inches in diameter and weighs 905 pounds. It has six joints, giving it six degrees of freedom. Its joints are roughly equivalent to human joints with a shoulder, [yaw and pitch], elbow [pitch], and wrist [roll, yaw and pitch]. At the end of the arm is the "end effector", used to grab the payloads.



The arm is normally installed on the left [port] of the payload bay but can be installed on the right [starboard]: 2 arms can be installed if necessary but only one can be controlled at a time.

STANDARD END EFFECTOR

The Standard End Effector is the RMS's equivalent of a hand. It is a hollow canister containing three cables which act as a snare to payloads which have special grapple fittings.

The End Effector snare mechanism can be "extended" to the open end of the canister, rotated and "closed" to capture the payload and/or withdrawn to "rigidize" the payload. The indicators on PANEL A8U show the status of the End Effector. The snare mechanism is opened or closed by the capture/release button on the aft rotational controller. Dependent on the MODE switch, the snare can be made rigid automatically once the snare has been closed or manually by use of the MAN CONTR switch.

The arm can be controlled with pre-programmed computer instructions by setting the rotary MODE switch on PANEL A8U to Auto 1,2,3,4 or OPR CMD, and pressing ENTER. The pre-programmed operations are then carried out.

Pre-programmed operations can be started, interrupted and restarted by momentary use of the AUTOSEQ PROCEED/STOP switch., or manually by using the [and] keys on your keyboard. Using these in conjunction with the ALT key moves it in fine steps.

Alternatively, the arm can be controlled by setting the rotary control to SINGLE, pressing ENTER, and then controlling the joint indicated on the JOINT rotary switch using the SINGLE/DIRECT DRIVE +/- switch. The DIRECT setting is a contingency mode which by-passes the computer intervention which normally ensures "within limit" control of the arm. The RMS status is shown on the CRT and the illuminated indicators on PANEL A8U.

The BACKUP panel is a downgraded control system to use if the primary circuits have failed. It is activated by setting the RMS POWER switch on Panel A8L to BACKUP. The payload can be released in emergency by use of the Backup PAYLOAD RELEASE switch on PANEL A8U. In the event of an emergency, in which the RMS arm cannot be stowed, and thus the Payload Bay Doors cannot be closed, the RMS arm can be jettisoned. There are four separate points on the arm, and all of them are jettisoned individually, using the switches on Panel A14.

JETTISONING THE ARM

To release the arm, first position the RMS JETT DEADFACE SWITCH to DEADFACE in order to kill the electronics in the retention latches. Then position the relevant PYRO RMS ARM SWITCH to GUILLOTINE, arming the jettison circuits. Positioning the RMS JETT SWITCH to GUILLOTINE cuts through the wire bundles in the arm. Then position the two switches to JETT, and the corresponding arm shoulder joint is jettisoned.

Finally, position the PYRO RETENTION LATCHES AFT, MID, FWD SWITCHES to GUILLOTINE and then to JETT, and the respective retention latches are also jettisoned.

Except in the case of those using the Payload Assist Module [PAM], payloads are normally latched into the payload bay itself. The payloads are unlatched by using the PL SELECT rotary switch on PANEL A6 [Numbered 1-5, each number relating to a payload], and releasing the latches using the well-named LATCH RELEASE switch. The indicator [one of three] above the switch shows LAT when the payload is latched and REL when the latches are fully released. Latching or unlatching a payload takes about 30 seconds. A captured payload can be latched when the ABC indicators show gray.

MANNED MANEUVERING UNIT

The MMU [Manned Maneuvering Unit] is used for occasions when objects to be retrieved are out of reach of a normal tether and the astronaut has to leave the safety of the Orbiter to float free in space.

First of all, the astronauts must don their space suits. This long and laborious affair involves a 3 hour 'pre-breathing' period in which the nitrogen in the astronauts' blood streams is purged by breathing pure oxygen from the space suit's life support systems.

This counteracts the effects of dysbarism, or the "bends", when the astronaut goes into the pressureless environment of space.

Once in their suits, the astronauts go through the airlock into the Payload Bay, and attach themselves to the MMU stowed there. It is a sort of Backpack with arm rests, as seen in all the best science fiction movies. The astronaut latches the hard MAIN MENU back of his space suit to the MMU, disconnects the tether, unclamps the MMU from its location on the Bay wall, and then propels himself out into space by using the hand controls at the end of each armrest. These control any or all of the 24 thrusters around the MMU that fire bursts

of nitrogen in the required direction, giving the astronaut full rotational or translational movement.



It is then simply a question of maneuvering the MMU to the satellite or whatever that has to be recovered, grabbing hold of it and pulling it back to the cargo bay.

In the unlikely event of the MMU's thrusters failing, the Orbiter can be maneuvered to within a short distance of the astronaut, who is then 'retrieved' by use of the RMS arm.

PAYLOAD DEPLOYMENT

The Payload Assist Module [PAM], formerly called the Spinning Solid Upper Stage, is designed as a higher altitude booster of satellites deployed in near Earth orbit but operationally destined for higher altitudes.

It is used to boost satellites to a geosynchronous transfer orbit [22,300 miles], or other higher energy orbits after deployment from the Shuttle. There are three versions of the PAM used on the Shuttle:

PAM-D - satellites of up to 2,750 lbs

PAM-DII - 4,150 lbs

PAM-A - 4,400 lbs

The PAMs are also used for non-geosynchronous transfer orbits.

The PAM's deployable stage consists of a spin-stabilized, solid-fuelled rocket motor, a Payload Attach Fitting [PAF] to mate with the unmanned spacecraft and the necessary timing, sequencing, power and control assemblies.

The PAM stages are supported through the spin table at the base of the motor and through restraints at the PAF. The forward restraints are retracted before deployment.

PAYLOAD RESCUE

- see MISSIONS - QUICK REFERENCE

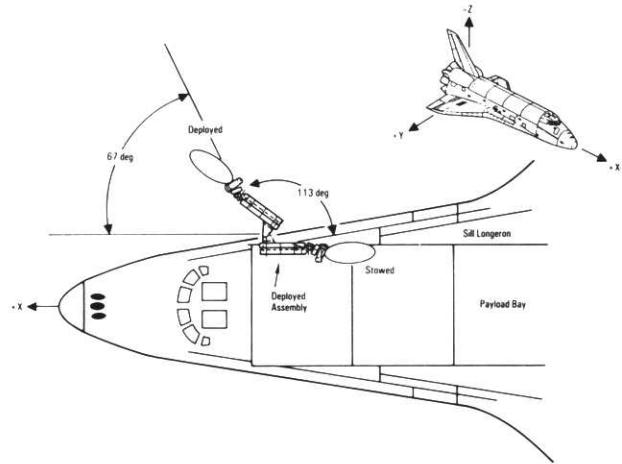
COMMUNICATIONS

AUDIO SYSTEM

The Audio System interfaces with the caution and warning system for reception of C/W [toner] signals; with UHF, S-band and KU-band systems for transmission and reception of external systems, both air to air and air to ground; and with the three TACAN sets for receiver selection and signal monitoring. With these systems the crew can talk to themselves, to ground control and to anyone else floating around in space [i.e. SPACELABS etc.]. During launch and descent the crew communicate through the headset built in to their helmets, which have their own push-to-talk buttons, as do the two RHCs, and for the rest of the time through the smaller 'snoopy caps' with their microphones and switches.

As you won't be able to talk to the space Shuttle, very few of the communications systems have been simulated, although you're asked to go through the motions of doing voice checks shortly before take-off, a process that involves the setting of switches on PANELS O5 & O9.

KU BAND ANTENNA



The Shuttle uses a KU band antenna to communicate with both the ground and with payloads that it's tracking. The KU antenna is stowed in the Payload bay and deployed shortly after the payload bay doors are opened.

CAUTION AND WARNING SYSTEM

The Caution and Warning System is designed to alert the crew when conditions exist that exceed predefined operating limits. The system is split into three categories: class 1, emergency; class 2, Caution and Warning; and class 3, alert.

The emergency system recognizes fire, indicated by a siren, or cabin depressurization, indicated by a klaxon. The Caution and Warning system generates an alternating alarm tone when an out of limit condition is detected by direct hardware or the GPCs on any one of 120 different parameters. Less critical conditions are notified by a steady alert tone.

SMOKE DETECTION AND FIRE SUPPRESSION

These facilities are to be found in the crew cabin avionics bays, crew cabin and, when relevant, the Spacelab pressurized module. Ionization detection sense smoke unusual concentrations, triggering alarms and relaying information to the CRTs and to the warning lights on Panel L1.

Smoke alarms are separated into Group A, in the life support system beneath the crew cabin floor, and Group B, in the right hand air duct on the flight deck, and in avionics bays 1,2 & 3A.

If the system detects a concentration of 2,200 +/- 200 micrograms per m², or an increase of 22 Mg/m² in 20 seconds, the smoke detection A or B light on and the C/W master alarm light, and sounds the siren in the crew cabin.

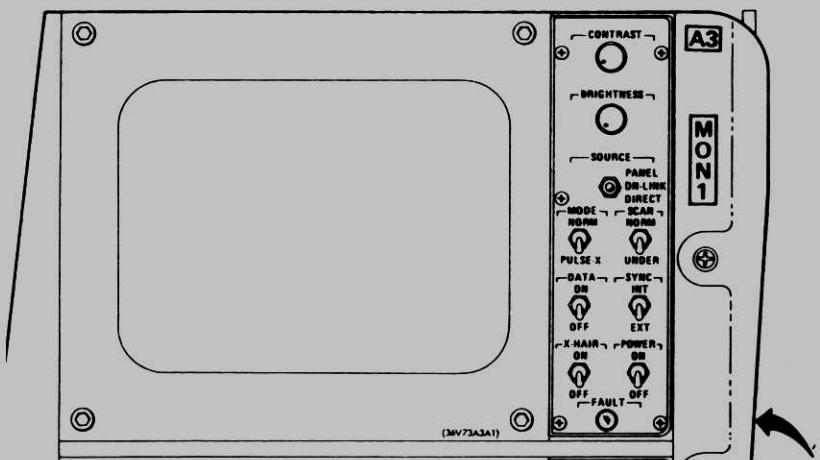
CLOSED CIRCUIT TELEVISION SYSTEM [CCTV]

The on-board cameras are used primarily for visual feedback to the crew of in-orbit operations and for the recording of these operations for future analysis by flight and ground crews.

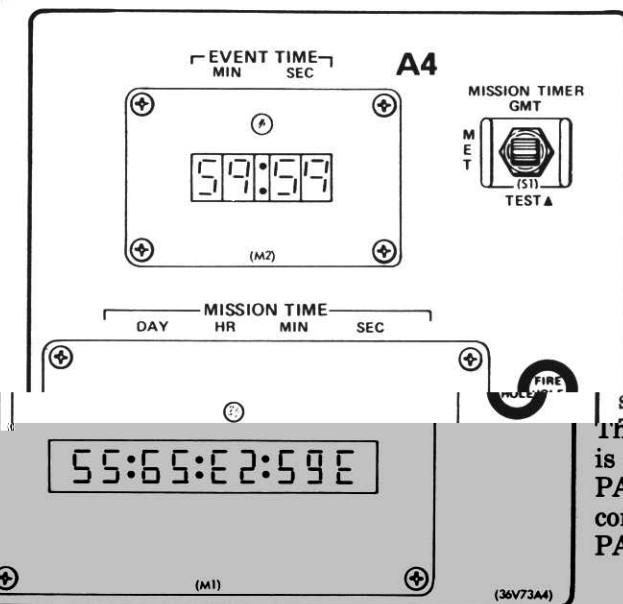
The cameras controlled by the astronauts and by Ground Control are nominally monochrome, but have an optional color capability. On-board monitors are monochrome only, color visual is available only to Ground Control due to hardware restrictions.

LOCATIONS

Cameras can be mounted at a number of locations within the payload bay, including two on the RMS arm. They are also used in the mid-deck and flight deck. Cameras are often mounted on an EVA unit deployed from the payload bay allowing views of virtually any external part of the Orbiter. Once the doors are open, it is often from this unit that the views of the Orbiter or Satellites set against the Earth are seen.



MISSION ELAPSED TIME



The Mission Elapsed Time [MET] is shown on PANELS O3 and A4. GMT can be shown instead using the mission timer switch on PANEL A4.

The Event timer is shown on PANEL F7 with control switches on C2. The art event timer is shown on PANEL A4 with control switches on PANEL A6.

FOOD

Even astronauts have to eat. The facilities for storage, preparation and consumption of the three daily meals are located on the middeck of the Orbiter. Gone are the days of space rations, when each meal consisted of a rehydrated powder that was 'almost exactly but not quite unlike food'. Today Shuttle crews have a choice of fresh and preserved foods that are as close to the real thing as you can safely get 200 miles up. No longer do the pilots have to smuggle their own food on board, as John Young did on his space flight in 1965. He offered his Commander a corn beef sandwich!

MEDICINE

The Shuttle is very well equipped in this department, carrying everything from codeine to cricothyrotomy sets. They must be able to deal with every emergency from a nose bleed to a heart attack - it's a long way to the nearest hospital!

Both Shuttle Orbiter Medical System [SOMS] and the Emergency Medical Kit [EMK] are located in a middeck forward locker, and consist of pallets containing various medical supplies, i.e., one has pills, another bandages, etc.

ELECTRICAL POWER DISTRIBUTION

The Shuttle is supplied with power from the ground until T-3 minutes 30 seconds. Thereafter, the Electrical Power System [EPS] supplies the Shuttle systems with electrical power [28 Volts DC]. The power is produced by reacting Hydrogen and Oxygen to produce electricity. As a by-product, water and heat for life-support is produced. The main controls are on PANEL R1, and while this panel is included in SPACE SHUTTLE - THE SIMULATOR, the electrical power distribution switches won't be active.

2. LANDING

The procedures for landing the Shuttle are laid out in SECTION 3 MISSION PROFILES, but the main components, (SSMEs, TACAN, GN&C, etc.) are also detailed earlier in the LAUNCH section. This section will therefore only contain those aspects of the Orbiter and its controls that haven't already been covered.

LANDING GEAR

The landing gear consists of steerable nose gear and left and right main gear located under the wings adjacent to the main fuselage. The main gear has brake assemblies with anti-skid protection. The landing gear is normally deployed at about 250 feet, around 15 seconds before touchdown at an air speed of less than 300 knots.

4. Mission Procedures

LAUNCH [MAJOR MODE 101]

At 31 seconds before launch, control is handed to the Onboard Computers. At T-6.6 seconds the GPCs start the three main engines and bring them up to 90% thrust by T-3 seconds. At a fraction before T-0 the SRBs are ignited and the Mission Timers started. Normally, this is all carried out by the OPS 1 software which was loaded automatically by the Launch Processing System at T-20 minutes.

MANUAL LAUNCH

In the event of an auto-Pilot failure on launch, the crew must ensure that the Orbiter is following the correct ascent profile by taking CSS control.

First, the Orbiter must be at the correct altitude [checked by the altitude/vertical velocity indicator, which displays the expected figure over the current one] and pitch attitude [by the attitude director indicator, as with altitude] at each of the five designated times during first stage ascent.

Then the crew must check that the engines throttle up and down, and that the 'Pc <50' chamber pressure message appears on the MM102 ascent trajectory CRT display before SRB separation, and that this occurs on time.

The crew can manually separate the SRBs by positioning the SRB SEPARATION switch on PANEL C3 to MAN and pressing the SEP button.

PRE-LAUNCH SEQUENCE

Time is annotated as minutes [sometimes hours], seconds and hundredths of a second.

T-50:00:00

Crew begins water-boiler pre-activation [see appropriate section]. Set the three BOILER PWR switches to ON, as well as the three BOILER N2 SPLY switches [PANEL R2].

T-32:00:00

Initiate primary avionics software system and backup flight system (BFS) transfer preparation.

Select the CRTs that you need for take-off by setting the BFS CRT SELECT switch [PANEL C3] to the 3 + 1 position. The CRTs won't display until powered up, however, so set the CRT 1/2/3 POWER switches to ON, and switch the LEFT CRT SEL to 1. Finally, enter ITEM 25 EXEC on the keypad. These last three operations are all on PANEL C2.

T-30:00:00

The Ground Crew secures the white room and retires to fall back area.

T-30:00:00

Crew begins Orbital Maneuvering System (OMS) pressurization. Set the two OMS ENG switches [PANEL C3] to ARM/PRESS.

T-30:00:00

Set CABIN VENT switch [PANEL L2] to OPEN - klaxon alarm should sound.

T-25:00:00

Pilot & Commander conduct voice checks with mission control. To do this, set the two respective ICOM MODE switches [PANELS O5/9] to VOX/VOX [Access to all external channels, voice activated] and then check both A/G [Air to Ground] switches, the A/A [Air to Air] switch and the two ICOM switches, all on panels O5/9, by setting them to T/R [Transmit/Receive].

NOTE

For the purposes of this version of SPACE SHUTTLE - THE SIMULATOR, the audio channels won't be synthesized. However, they do still have to be checked or the Shuttle won't be cleared for takeoff.

T-21:00:00

Set both CABIN VENT switches [PANEL L2] to CLOSE.

T-21:00:00

Under normal circumstances, there is a planned 10 minute hold here, in case of any contingencies. For the purposes of SPACE SHUTTLE - THE SIMULATOR, however, this won't be implemented.

T-20:00:00

Now the crew begins the entry procedure for Flight Plan OPS-1, Major Mode 1 - Launch. First set ERR LOG switch [PANEL C2] to RESET, at which any faults in the GN&C system will be indicated on CRT1. Then enter SPEC 99 PRO on the keypad - CRT2 will now indicate the launch trajectory.

T-19:00:00

Now set GPC POWER switch 5 [PANEL O6] to ON, followed by SPEC 99 PRO again. This sets the BFS running, to be used in case of emergency. Then enter OPS 101 PRO on the keypad, followed by SPEC 99 PRO once more, setting the Orbiter's computers on course for launch.

T-16:00:00

Begin Main Propulsion System (MPS) helium pressurization by setting the six MPS He ISOL A, B switches [PANEL R2] to OPEN.

T-15:00:00

First abort check. Mission Control cycles the ABORT light [PANEL F6] thru bright, dim, then off, three times. This is followed by a 10 minute hold, if necessary.

T-09:00:00

Resume countdown and prepare for launch. Set EVENT TIMER switch [PANEL C2] to START and check that the indicator is counting down.

T-08:00:00

Switch the AC [Alternating Current] sensors to the monitor by setting the three AC BUS SNSR switches [PANEL R1] to OFF for 1 second, then to MONITOR.

T-07:00:00

Crew-access arm retracts. The crew is now isolated in the Orbiter.

T-06:00:00

Auxiliary power unit (APU) prestart. On PANEL R2, check that the three BOILER N2 SUPPLY switches and the three BOILER PWR switches are ON; check the three BOILER CNTLR/HTR switches are at position A, that the three APU FUEL TK VLV switches are closed, and both APU FUEL PUMP/VLV COOL switches are at OFF.

Also on PANEL R2, ensure that the three APU CNTLR PWR switches are at ON, that the three HYD CIRC PUMP are set to GPC, the three APU AUTO SHUT DOWN switches to ENA and the three APU SPEED SEL switches to NORM. Finally, set the three APU CONTROL switches to OFF and the three HYD MAIN PUMP PRESS selector switches to LOW. This completes the APU prestart checks.

T-05:00:00

Now the crew starts up the APUs. On PANEL R2, set the APU FUEL TK VLV switch to OPEN, No.1 APU OPERATE switch to START/RUN and No.1 HYD MAIN PUMP PRESS 1 to NORM.

In addition, check the HYDRAULIC PRESSURE 1 indicator on PANEL F8, it should be at HI green. This should also be true for APU Fuel/H₂O Qty gauges 2&3.

Finally, on PANEL R2, switch off all three HYD CIRC PUMP switches and check the HYD PRESS light on PANEL F7 - it should be off.

T-04:30:00

All external power links are withdrawn and the Orbiter switches to its own internal power. From now on most operations are expedited automatically from the GPC.

T-03:45:00

Orbiter aero surfaces are moved to condition the hydraulic system for take-off.

T-03:00:00

Orbiter main engines gimbal to their launch positions.

T-02:55:00

External Tank oxygen vents close and liquid oxygen tank begins pressurizing.

T-02:00:00

The crew now configures for lift-off. First, the Commander & Pilot set volume levels on PANELS O5&9 to their requirements [not active on this version], then set the three APU AUTO SHUT DOWN switches [PANEL R2] to INHIBIT.

T-01:57:00

The External Tank hydrogen vents close; liquid hydrogen tank pressure builds up for flight.

T-00:25:00

Solid Rocket Booster APUs start. Management of countdown switches over to GPCs.

T-00:03:80

Computers command Space Shuttle Main Engines (SSMEs) to start.

T-00:03:46

First SSME ignites, followed by the other two at intervals of twelve hundredths of a second.

T-00:00:00

Crew checks main engine status - the MPS PRESS P_c gauge on PANEL F7 should read higher than 90% and the Main Engine Status lights should now all be on green. A 2.64 second timer for SRB ignition begins before the SRBs ignite at T+00:02:64, with Lift off 36/100 of a second later at T+00:03:00.

This ends the Pre-Launch stage.

FIRST STAGE [MM102]

The computer controls the vehicle vertically upwards until the tower lightning rod is cleared by about 41 feet. The Shuttle now begins a combined pitch, yaw and roll maneuver which leaves the Orbiter flying upside down during the ascent. No crew interaction takes place during MM102 other than to monitor the instruments and in particular the MM102 CRT Launch trajectory display, unless a malfunction occurs [see MANUAL LAUNCH, below]. The main engines are throttled back at about 26 seconds and back up at 60 seconds just before the point of maximum dynamic pressure. At around 2 minutes, SRB separation takes place and command passes automatically to the computer, which initiates MM103.

T+00:06:50

Launch tower cleared.

T+00:11:00

Roll into 'heads down' position starts.

T+00:30:00

Roll maneuver complete.

T+00:30:00

Crew sets the ADI ATTITUDE switches on PANELS F6/8 so that it gives local vertical/horizontal (LVLH) readings.

T+00:44:00

Using the SPEED BK/THROT, the crew throttle down the SSMEs from 100% to 65%, checking this with the SPEEDBRAKE % gauge on PANEL F7, as well as the AVVI on PANELS F6/8.

T+01:06:00

SSMEs throttle back up to 100% in the same way.

T+02:00:00

SRBs burn out. This is checked by the crew on the CRT; when combustion chamber pressures are less than 50 psi, the crew receives the $P_c < 50$ signal.

T+02:07:00

SRB separation. This happens automatically, for contingency, see SRB in the REFERENCE SECTION.

SECOND STAGE [MM103]

The computers continue to control the Shuttle's attitude through from SRB separation to Main Engine Cutoff [MECO]. The crew monitors the instrumentation, especially the MM103 CRT Ascent Trajectory Display. Just before MECO, the engines are gently throttled back to 65%. Just after MECO, the ET is jettisoned.

If this fails, the crew can manually separate the ET by positioning the ET SEPARATION switch on PANEL C3 to MANU and pressing the SEP button. The umbilical doors can be manually closed using the ET UMBILICAL DOOR switches on PANEL R2. The Orbiter uses RCS control to maneuver clear of the ET. After successful ET Separation, Mission Control will give a "Go for Orbit" message and the computer will be allowed to enter MM104.

T+04:20:00

Ground Control sends a Negative Return Call: this tells the crew that an RTLS Abort is no longer possible.

T+06:30:00

The Shuttle now begins a long shallow dive to prepare for ET separation.

T+07:00:00

Orbiter reports to Mission Control that they can now reach orbit even if two main engines fail.

T+07:40:00

By using the SPEEDBK/THROT, the crew throttles down the Main Engines to keep acceleration less than 3g's.

T+08:28:00

Engines again throttle down to 65% of thrust.

T+08:38:00

MECO: the three engines shut down. MAIN ENGINE STATUS indicators on PANEL F7 should all be red, indicating MECO.

T+08:54:00

External Tank separation. For manual separation, see EXTERNAL TANK in the REFERENCE SECTION.

ORBIT INSERTION [MM104 AND MM105]

After MECO and ET separation, the Shuttle is inserted into orbit by either one or two OMS burns called OMS-1 and OMS-2 respectively. One OMS burn is called "direct insertion". Direct insertion is the term used to describe the use of only one burn. The MM104 period covers the OMS-1 burn and the MM105 period covers any OMS-2 burn.

T+09:00:00

With the negative Z translation [Tail Maneuver] complete, the crew now prepares for Orbital Maneuvering System burn #1 (OMS-1) in preparation for orbital insertion.

T+10:39:00

The crew now begins the first OMS burn or OMS-1. On PANELS F6/8, the ADI ATT switches are set to INRTL, the crew then checks that the Digital Auto-Pilot [DAP] switch on PANEL C3 is set to AUTO. Finally, the crew enters ITEM 27 EXEC on the keypad. OMS-1 is cut off at just under two minutes, T+12:24:00.

T+12:30:00

Now the crew undergoes post-OMS-1 activities, beginning with auxiliary power shutdown. This process is almost exactly the reverse of APU START. First the three APU AUTO SHUT DN switches are set to ENA, then the three BOILER CNTLR switches, the three APU CNTLR/PWR switches and finally the APU OPERATE switch are all set to OFF. All four sets of switches are on PANEL R2.

The computer program is then changed, with the code OPS 105 PRO being entered on the keypad.

Next the External Tank umbilical doors are closed and latched, setting the ET UMBILICAL DOOR switch to GPC/MAN, the L & R DOOR to CLOSE, the L & R DOOR LATCH switches to LATCH and the CENTERLINE LATCH to STOW, all on PANEL R2.

This is the last operation for over half an hour, during which the crew has a chance to further acclimatize themselves to space travel which is always a shock no matter how much training has been done. At this point, the crew also takes time to further acquaint themselves with the Control Panel Layouts and to have a good look at the Earth from 70 miles plus above the ground.

T+45:58:00

Eventually the crew has to do some work, however, they now have to prepare for the OMS-2 burn that will insert them into low-Earth orbit by setting the two OMS ENG switches [PANEL C3] to ARM/PRESS. Fifty seconds later OMS-2 cut off is achieved and the computer must be set to a new program by entering OPS 106 PRO on the keypad.

The Orbiter and its crew are now in orbit. This is the end of the launch sequence.

NORMAL LANDING SEQUENCE

DE-ORBIT [MM301-303]

To de-orbit, the crew select OPS 3, MM301. The life-support system coolers are checked out and the payload bay doors closed. The Orbiter is maneuvered to its de-orbit attitude [i.e., pointing "backwards"] and the entry targets programmed. The de-orbit burn is selected by entering MM302, which fires the OMS engines to slow the craft at the correct time. After the burn, MM303 is selected and the craft is turned to enter the atmosphere nose first.

During OPS 3 the OMS CRT display is available via the PASS CRT displays on the Forward Center console.

L-02:00:00:00

With the Shuttle now orbiting at 17,300 mph and ready for re-entry, the crew unstows any seats required for mission and payload specialists and advises all crew members to go to their landing positions. They then enter the de-orbit code, OPS 301 PRO into the computer.

L-01:40:00:00

The crew prepares for de-orbit burn by checking the OMS engine status on PANEL O8. The four L/R He PRESS/VAPOR ISOL switches must be CLOSED, the eight TANK ISOL switches OPEN and the four CROSSFEED switches CLOSED.

Then the aft LEFT & RIGHT RCS is checked on PANEL O7. The two He PRESS switches should be OPEN, the six TANK ISOL switches and the LEFT/RIGHT RCS CROSSFEED switches set to GPC and the MASTER RCS CROSSFEED turned OFF.

L-01:24:00:00

Then, the OMS engines having been checked, the crew initiates the APU pre-start, all controls found on PANEL R2. The three BOILER N2 SUPPLY switches and the three BLR CNTLR switches should be ON, the three BOILER CNTLR PWR/HTR switches set to position A and the three APU FUEL TK VLV switches CLOSED.

L-01:21:00:00

The crew then loads the de-orbit computer program by entering OPS 302 PRO on the keypad.

L-01:17:00:00

Crew receives the Go/No go decision from Mission Control for de-orbit, entry and landing.

L-01:15:00:00

The crew now maneuvers to a de-orbit burn attitude, i.e., turning the Orbiter around so it's flying tail first. First, from PANELS F6&8, they have to set the FLT CNTLR POWER SWITCH to ON, the ADI ATT switches to INRTL, the ADI ERROR to MED and the ADI RATE to MED.

Next, with Rotation Hand Controller, the crew must maneuver to burn attitude. To do so, compare the pre-determined attitude shown on the CRT with that shown on the ADI.

L-01:03:00:00

The crew now starts up a single APU.

On PANEL R2, set the #1 APU FUEL TK VLV switch to OPEN and the #1 APU OPERATE switch to START/RUN. The three HYD CIRC PUMP switches should be OFF and the HYD PRESS indicator on PANEL F8 should be LO green.

L-01:02:00:00

The crew now arms the OMS engines. The DAP on PANEL C3 is set to AUTO, while the L/R OMS He PRESS/VAPOR ISOL A switches [PANEL O8] go to GPC and the L/R OMS ENG switches go to ARM/PRESS.

L-01:00:15:00

The crew now enters EXEC on the keypad, beginning the countdown for de-orbit burn. This should last for 2-3 minutes, the crew confirms this with Ground Control after the burn is complete.

L-54:00:00

The Shuttle is now at an orbit of 17,100 mph and descending. Now the crew commences their post-OMS burn activities.

On PANEL O7, the crew checks the aft left and right RCS. The four He PRESS switches should be OPEN, with the six TANK ISOL switches and the four CROSSFEED switches at GPC.

On Panel O8, the crew checks the left and right OMS engine status. The four He PRESS VAPOR SOL switches and the four CROSSFEED switches should be CLOSED, while the four TANK ISOL SWITCHES should be OPEN.

L-52:00:00

Now the crew positions the Orbiter for entry by entering OPS 303 PRO, then ITEM 24 [for roll], ITEM 25 [for pitch] and ITEM 26 [for yaw].

After the ORBITAL DAP [PANEL C3] is set to MAN, the crew maneuvers the Orbiter into the position shown on CRT #1. The Orbiter should face forward with its nose pointed up between 28 and 38 degrees.

L-50:00:00

The switch positions are now checked and set for entry.

On PANEL L2, CABIN RELIEF A & B go to ENA, the ANTISKID is turned ON, while the NOSE WHEEL STEERING and the ENTRY ROLL MODE are both turned OFF.

Then the SPEED BRK/THROT, the SRB SEP and ET SEP switches [both on PANEL C3] are all set to AUTO, ready for entry.

On PANELS F6&8, the AIR DATA switches go to NAV, the ADI ERROR and the ADI RATE to MED, while the three HYD MAIN PUMP PRESS switches [PANEL R2] are set to NORM, at which time the HYDRAULIC PRESSURE indicators [PANEL F8] should be on HI green.

L-41:00:00

The crew now move the Orbiter aero control surfaces to prepare the hydraulic system for entry and landing.

On the computer keyboard, ITEM 39 EXEC is entered.

L-40:00:00

All propellants in the forward reaction control system are now dumped overboard. This shifts the Orbiter's balance on point of entry. On the computer keyboard, enter ITEM 36 EXEC, then ITEM 37 EXEC, then ITEM 38 EXEC.

L-36:00:00

The crew now stops the movement of the aero control surfaces by entering ITEM 40 EXEC on the keypad.

L-35:00:00

The crew now checks entry attitude. On PANELS F6 & F8, the ADI should show Roll and Yaw at 0 degrees and Pitch at 28-38 degrees.

L-35:00:00

The crew now inflates their anti-G suits, ready for entry.

L-35:00:00

The computer program is now changed to the next phase, entering OPS 304 PRO, followed by a check of the switch positions.

SPD BK/THROT and ROLL/YAW should be at AUTO, while BODY FLP should be on MAN.

RE-ENTRY [MM304]

The Entry Interface [EI] occurs at about 400,000 ft. Five minutes before EI, the Orbiter is at about 557,000 ft traveling at about 17,300 mph, about 4,400 nautical miles from the landing site and MM304 is entered. During the re-entry phase, a complete loss of communication blackout occurs. This phase continues through the Terminal Area Energy Management Interface [TAEM] at around 83,000 ft, 1,700 mph, 52 nautical miles from the runway. Here the Orbiter circles, slows down and descends, in line with the TAEM "alignment cylinder" as seen on the SPEC 50 CRT display. On the display the pilot sees the cylinder and the angle by which he must bank around it to correctly line up with the runway. The Orbiter continues to descend until it is at around 10,000 ft at 700 mph and on track to the runway. At this point the landing phase [MM305] begins. TACAN Acquisition is completely automatic at around 120 nautical miles, though the flight crew can take over control of the vehicle navigation and/or control at any time [see below]. During MM304 a series of 5 CRT displays are monitored by the crew.

L-30:00:00

Orbit is now at 400,000 ft and still at 17,100 mph, atmospheric entry now begins. Set BODY FLP [PANEL F2] to AUTO.

L-25:00:00

Orbit is now 312,000 ft, at 16,700 mph. Communication blackout begins and RCS roll thrusters deactivate.

L-23:00:00

The Shuttle is now orbiting at 15,000 mph, RCS pitch thrusters deactivate.

L-20:00:00

The Shuttle is now at 230,000 ft and doing 15,000 mph. The Orbiter is at its maximum outside temperature.

L-16:00:00

The crew performs their first roll reversal (S-turn).

First the ADI RATE is switched to HI, then the ROLL/YAW to CSS, both on F6&8. The RHC is then used for the maneuver.

L-12:00:00

At 180,000 ft, and 8,300 mph, the Orbiter leaves the communication blackout.

L-12:00:00

The second roll reversal is now performed by moving the RHC in the opposite direction to the last S-turn.

L-10:00:00

The speed brake should now be at 100%.

L-07:00:00

Now the third roll reversal is performed. With the Pilot or Commander, move the RHC in the opposite direction again.

L-06:00:00

At 90,000 ft, and Mach 3.3, move the speed brake to 65% and set the AIR DATA PROBE switches [PANEL C3] to DEPLOY.

L-05:30:00

The fourth S-Turn comes at 83,000 ft, Mach 2.5.

L-05:30:00

The crew now begins Terminal Area Energy Management (TAEM), heading for the alignment cylinder, Waypoint One, to line up on the runway for the final approach.

L-03:00:00

At 50,000 ft, Mach 1.0, the RCS yaw thrusters deactivate. The crew now uses their rudder pedals for yaw control.

L-02:00:00

Autoland guidance begins at 13,300 ft. At this time the Orbiter will be doing around 420 mph. The CSS switches for PITCH and ROLL/YAW [PANEL F2] should now be switched ON. The crew now has full manual control using the RHC and speed brake as required to hold a 22 degree glideslope.

MANUAL RE-ENTRY

The crew will observe the same CRT displays as for MANUAL LAUNCH [see above] and will be able to guide the Orbiter down by use of Ground Control attitude information, comparing it with current attitude, pitch, etc. and adjusting it accordingly.

For full details see MISSION PROFILES below.

LANDING [MM305]

The MM305 computer program takes the Orbiter down the steep glideslope, about 18 degrees. At a height of 1,750 ft, the crew lowers the landing gear using the ARM and DN push buttons on PANEL F6 or F8, thereby completing the pre-flare maneuver to take the Orbiter on a 1.5 degree glideslope to the runway. The final flare is made about 80 ft above the runway to reduce the descent to a safe 9 ft per second or less. The Orbiter touches down at around 220 mph. MSBLS Acquisition is completely automatic at around 8 nautical miles, though the flight crew can take over control of the vehicle navigation and/or control at any time [see below]. During MM305 the Horizontal situation can be monitored on the CRT by the crew.

MANUAL LANDING

Once under atmospheric conditions and having gone through all the usual fuel dump processes, the Orbiter handles like any other aerodynamic object. The wing and tail PANELS are used to slow down and correctly align the Orbiter for landing, checking attitude, speed, pitch, etc. with the CRT displays.

L-00:30:00

Crew begins pre-flare at 2,000 ft., 350 mph. Using RHC and speed brakes, the glideslope is adjusted to 1.5 degrees. Enter OPS 305 PRO on the keypad.

L-00:17:00

Pre-flare is completed at around 135 ft., with the Shuttle doing around 340 mph. The landing gear is now armed by lifting the cover of the LANDING GEAR ARM switch [PANEL F6] and pushing.

L-00:14:00

Landing gear is deployed at 90 ft., at 330 mph. The cover of the LANDING GEAR DN switch [PANEL F6] is lifted and the button pushed.

L-00:00:00

0 ft., 215 mph - Touchdown!

Set the Speed brake to 100% and use the RHC to pitch forward in order to lower nose and full forward when the nose wheel touches down. Using pedals, brake as required.

Set SRB SEP switch [PANEL C3] to MAN/AUTO and ET SEP [Also C3] to AUTO. Lift the covers on the SRB and ET SEP buttons and push.

L+00:02:00

At 0 ft, 0 mph, the Orbiter has finally stopped. Push the Speed brake full forward to maximum.

Next, turn off the APU's by setting the three APU AUTO SHUT DOWN switches [PANEL R2] to ENA.

L+00:04:00

Deactivate the OMS and RCS systems to turn the Orbiter over to the ground crew.

On PANEL C3, turn off both the OMS ENG switches. On PANEL O7, set the following switches:

For L & R aft RCS:
MANIFOLD ISOL [10] - OPEN
TANK ISOL [6] - OPEN
He PRESS [4] - CLOSED
CROSSFEED [4] - CLOSED

On PANEL O8, for L & R OMS:

He PRESS/VAP ISOL [4] - OPEN
CROSSFEED [4] - CLOSED

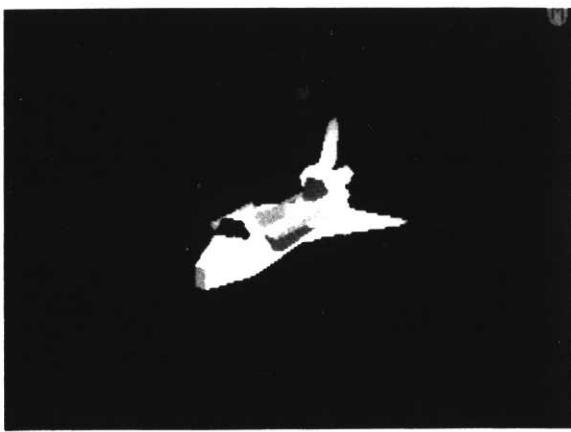
For forward RCS:

MANIFOLD ISOL [5] - OPEN
TANK ISOL [2] - OPEN
He PRESS [2] - OPEN

On the computer keyboard, enter OPS 901 PRO, turning the Shuttle off.

Roughly 27 minutes after touchdown, the crew can leave the Orbiter and enter the egress vehicle via the egress slide.

5. Mission Profiles



From April 1981 through January 1986, Twenty-five Space Shuttle launches were conducted. All four Orbiters in the fleet: Columbia, Challenger, Discovery and Atlantis, were flown. However, 1 minute, 13 seconds after liftoff during the twenty-fifth launch of the Space Shuttle

Challenger, on January 28, 1986, the Space Shuttle exploded. The Orbiter Challenger was destroyed and its crew of seven killed. The accident had a far-reaching impact on the Space Shuttle program. Launchings were suspended for more than 2 years and recommendations of the Presidential Commission which investigated the accident were implemented, along with changes called for by NASA itself.

STS-1

The first launch of the Space Shuttle occurred on April 12, 1981, when the Orbiter Columbia with two crew members, astronauts John W. Young, Commander and Robert L. Crippen, pilot, lifted off from Pad A, Launch Complex 39 at the Kennedy Space Center. It was the first of twenty-four launches from Pad A. It was exactly 7 a.m. EST. Two days earlier a launch attempt was scrubbed because of a timing problem in one of the Columbia's general purpose computers.

Not only was this the first launch of the Space Shuttle, it also marked the first time that solid fuel rockets were used for a U.S. manned launch. The STS-1 Orbiter Columbia also holds the record for the amount of time spent in the Orbiter Processing Facility (OPF) before launch. Six hundred ten days were required for the replacement of many of its heat shield tiles.

Primary mission objectives of the maiden flight were to check out the overall Shuttle system, accomplish a safe ascent into orbit and to return to Earth for a safe landing. All of these objectives were met successfully and the Shuttle's worthiness as a space vehicle was verified.

The only payload carried on the mission was a Development Flight Instrumentation (DFI) package which contained sensors and measuring devices to record Orbiter performance and the stresses that occurred during launch, ascent, orbital flight, descent and landing.

The 36-orbit, 933,757 mile-long flight lasted 2 days, 6 hours, 20 minutes and 32 seconds. Landing took place on Runway 23 at Edwards AFB, California, on April 14, 1981, at 10:21 a.m. PST. Post-flight inspection of the Columbia revealed that an overpressure wave which occurred when the SRB ignited resulted in the loss of 16 heat shield tiles and damage to 148 others. In all other respects the Columbia came through the flight with flying colors. The Columbia was returned to Kennedy Space Center from California on April 28, 1981 atop its 747 carrier aircraft.

STS-2

Launch of the second Space Shuttle took place 7 months later on November 12, 1981 with liftoff at 10:10 a.m. EST. The planned launch time of 7:30 a.m. was delayed while a faulty data transmitting unit of the Columbia was replaced. Originally the launch had been set for October 9, 1981, but was delayed by a nitrogen tetroxide spill during loading of the forward Reaction Control System (RCS) tanks. Launch was rescheduled for November 4, 1981, but it was again scrubbed when high oil pressures were discovered in two of the three Auxiliary Power Units (APU) that control the Orbiter's hydraulic system. Prior to launch, the Columbia had spent 102 days in the OPF.

The flight marked the first time a manned space vehicle had been reflown with a second crew: Joseph H. Engle, Commander, and Richard H. Truly, pilot. It again carried the DFI package as well as the OSTA-1 payload, named for the NASA Office of Space and Terrestrial Applications which consisted of a number of remote sensing instruments mounted on a Spacelab pallet in the payload bay. These instruments, including the Shuttle Imaging Radar-A (SIR-1), successfully carried out remote sensing of Earth resources, environmental quality, ocean and weather conditions. In addition, the Canadian-built Remote Manipulator System (RMS) arm was successfully operated in all of its various operating modes for the first time.

Although the STS-2 mission had been scheduled to last 5 days, the flight was cut short when one of the three fuel cells that produce electricity and drinking water failed.

Landing took place on Runway 23, Edwards AFB, at 1:23 p.m. PST, November 14, 1981 after a 36-orbit, 933,757-mile flight that lasted 2 days, 6 hours, 13 minutes, 13 seconds.

Despite the truncated flight, more than 90 percent of the mission's objectives were achieved. Moreover, modifications of the water sound suppression system at the pad to absorb the solid rocket booster overpressure wave during launch were effective; no tiles were lost and only 12 were damaged. The Columbia was flown back to KSC on November 25, 1981.

STS-3

The Columbia was launched on its third flight at 11:00 a.m. EST, on March 22, 1982, the planned launch date. The launch was delayed for 1 hour because the heater on a nitrogen gas ground support line failed. The Columbia had spent only 70 days in the Orbiter Processing Facility, a record checkout time. The two-man crew included Jack R. Lousma, Commander and Charles G. Fullerton, pilot.

Major objectives of the flight were to continue testing the RMS arm and to carry out extensive thermal testing of the Columbia by exposing its tail, nose and top to the sun for varying periods of time.

In its payload bay, the Columbia again carried the DFI package and OSS-1. Named for the NASA Office of Space Science and Applications, the OSS-1 consisted of a number of instruments mounted on a Spacelab pallet to obtain data on the near-Earth environment and the extent of contamination caused by the Orbiter itself. A test canister for the Small Self-Contained Payload program, also known as the Getaway Special (GAS), was mounted on a side of the payload bay.

For the first time a number of experiments were carried in the middeck lockers. These included a Continuous Flow Electrophoresis System experiment to study separation of biological components and a Monodisperse Latex Reactor experiment to produce uniform micron-sized latex particles. The first Shuttle Student Involvement Project (SSIP), the study of insect motion, was also carried out in a middeck locker.

During the flight, both crew members experienced some space sickness, the toilet malfunctioned, one Auxiliary Pacer Unit overheated (but worked properly during descent) and three communications links were lost.

STS-3 was planned as a 7-day flight but was extended an extra day because the planned landing site at Edwards AFB was too wet for a safe landing and the backup landing site, Northrup Strip, White Sands, N.M., was experiencing high winds.

Touchdown finally took place at 9:05 a.m. MST, March 30, 1982, at Northrup Strip (later renamed White Sands Space Harbor). The Columbia had made 129 orbits and travelled 3.3 million miles during its 8-day, 4-minute, 45-second flight. A total of 36 tiles were lost and 19 were damaged. It was returned to KSC on April 6, 1982.

STS-4

This mission marked the first time the Space Shuttle was launched precisely at its scheduled launch time. It also was the last research and development flight in the program. Liftoff took place on June 27, 1982 at 11:00 a.m. EST, with Thomas K. Mattingly as Commander, and Henry W. Hartsfield as pilot. Its cargo consisted of the first Getaway Special payloads which included nine scientific experiments provided by students from Utah State University and a classified Air Force payload.

In the middeck, The Continuous Flow Electrophoresis System and the Monodisperse Latex Reactor were flown for the second time. The crew conducted a lightning survey with handheld cameras and performed medical experiments on themselves for two student projects. They also operated the RMS with an instrument called the Induced Environment Contamination Monitor designed to obtain information on gasses or particles being released by the Orbiter in flight.

STS-4 was a planned 7-day mission. Landing occurred on July 4, 1982, at 9:10 a.m. PDT, on the 15,000 ft. concrete Runway 22 at Edwards AFB. It was the first Shuttle landing on a concrete runway.

The flight lasted 7 days, 1 hour, 9 minutes, 40 seconds. Distance traveled was 2.9 million miles in 112 complete orbits. All mission objectives were achieved although the two SRBs were lost at sea when their main parachutes failed. The Columbia was returned to KSC on July 15, 1982.

STS-5

STS-5 was the first operational mission. It carried a crew consisting of four astronauts and the first two commercial communications satellites.

The fifth launch of the Orbiter Columbia took place at 7:19 a.m. EST, November 11, 1982. It was the second on-schedule launch. The crew included Vance Brand, Commander, Robert F. Overmyer, pilot and the first mission specialists to fly the Shuttle, Joseph P. Allen and William B. Lenoir.

The two communications satellites were deployed successfully and were subsequently propelled into their operational geosynchronous orbits by booster rockets. Both satellites were Hughes-built HS-376 series satellites, SBS-3 owned by Satellite Business Systems and Anik owned by Telesat of Canada. In addition to the first commercial satellite cargo the flight carried a West German-sponsored microgravity GAS experiment canister in the payload bay. The crew also conducted three student experiments during the flight.

A planned spacewalk by the two mission specialists had to be cancelled because the two space suits that were to be used developed problems.

The Columbia landed on Runway 22 at Edward AFB, on November 16, 1982, at 6:33 a.m. PST, having traveled 2 million miles in 81 orbits during a mission that lasted 5 days, 2 hours, 14 minutes and 26 seconds. The Columbia was returned to KSC on November 22, 1982.

STS-6

On April 4, 1983, STS-6, the first Challenger mission, lifted off at 1:30 p.m. EST. It was the first use of a new lightweight external tank and lightweight SRB casings.

The mission had originally been scheduled for launch on January 30, 1983. It was delayed due to a hydrogen leak in one of the main engines and fuel line cracks found in the other two engines. The engine with the hydrogen leak was replaced and the other two engines were removed, repaired and re-installed.

Meanwhile, as the engine repairs were underway, a severe storm caused contamination of the primary cargo for the mission, the first Tracking and Data Relay Satellite (TDRS), while it was in the Payload Changeout Room on the Rotating Service Structure at the

launch pad. This meant the satellite had to be taken back to its checkout facility where it was cleaned and rechecked.

STS-6 carried a crew of four - Paul J. Weitz, Commander, Karol J. Bobko, pilot, Donald H. Peterson and Story Musgrave, mission specialists. Using new space suits designed specifically for the Space Shuttle, Peterson and Musgrave successfully accomplished the program's first extravehicular activity (EVA), performing various tests in the payload bay. Their space walk lasted 4 hours, 17 minutes.

Although the 5,000 lb. TDRS was successfully deployed from the Challenger, its two-stage booster rocket, the Interim Upper Stage (IUS), shut down early, placing the satellite into a low elliptical orbit. Fortunately, the satellite contained extra propellant for its attitude control system thrusters. During the next several months the thrusters were fired at carefully planned intervals gradually moving TDRS-1 into its geosynchronous operating orbit, saving the \$100-million satellite.

Other STS-6 cargo included three GAS canisters and continuation of the Monodisperse Latex Reactor and the Continuous Flow Electrophoresis experiments.

Challenger returned to Earth on April 9, 1983, at 10:53 a.m. PST, landing on Runway 22 at Edward AFB. It completed 80 orbits, travelling 2 million miles in 5 days, 24 minutes, 32 seconds. It was flown back to KSC on April 16, 1983.

STS-7

The Challenger's second flight began at 7:33 a.m. EST, June 18, 1983, with another on-time liftoff. The five person crew was the largest to fly in a space craft up to that time and also marked the first flight of an American woman in space, Sally K. Ride.

Crew members included Robert L. Crippen, Commander, making his second Shuttle flight, Frederick C. Hauck, pilot, Sally Ride, John M. Fabian and Norman Thagard, all mission specialists. Thagard conducted medical tests of the Space Adaptation Syndrome nausea and sickness frequently experienced by astronauts during the early phase of a space flight.

Two communications satellites - Anik C-2 for Telesat of Canada and Palapa B-1 for Indonesia were successfully deployed during the first 2 days of the mission. The mission also carried the first Shuttle Pallet Satellite (SPAS-1) built by Messerschmitt-Bolkow-Blohm, a West

German aerospace firm. SPAS-1 was unique in that it was designed to operate in the payload bay or be deployed by the RMS as a free flying satellite. It carried 10 experiments to study formation of metal alloys in microgravity, the operation of heat pipes, instruments for remote sensing observations and a mass spectrometer to identify various gases in the payload bay. It was deployed by the RMS and flew alongside and over the Challenger for several hours while a U.S. supplied camera took pictures from the SPAS-1 of the Orbiter performing various maneuvers. The RMS later grappled the pallet and returned it to the payload bay.

This mission also carried seven GAS canisters which contained a wide variety of experiments as well as the OSTA-2 payload, a joint U.S.-West German scientific pallet payload. Finally, the Orbiter's Ku-band antenna was able to relay data through the Tracking and Data Relay Satellite to a ground terminal for the first time.

STS-7 was scheduled to make the first Shuttle landing at the Kennedy Space Center's Shuttle Landing Facility, however, unacceptable weather forced a change to Runway 23 at Edwards AFB. The landing took place June 24, 1983, at 6:57 a.m. PDT. The mission lasted 6 days, 2 hours, 23 minutes, 59 seconds, covering about 2.2 million miles during 97 orbits of the Earth. The Challenger was returned to KSC on June 29, 1983.

STS-8

The Challenger was back in space on August 30, 1983 after it lifted off at 2:32 a.m. EDT, following a 17-minute delay due to bad weather. It was the first night launch in the Space Shuttle program. The launch was required for tracking requirements of the primary payload, the Indian National Satellite, INSAT 1B, a multipurpose satellite owned by India. The satellite was deployed successfully on the second day of the flight.

The 5-member crew included the first black American to fly in space, mission specialist Guion S. Bluford Jr., Commander, Richard H. Truly, making his second Shuttle flight, pilot, Daniel C. Brandenstein and mission specialists, Bluford, Dale A. Gardner and William Thornton.

In addition to INSAT, the payload bay carried 12 GAS canisters. Four contained experiments while the remaining eight canisters contained special STS-8 postal covers. Two other boxes of covers were mounted on an instrument panel, bringing the total number of the special philatelic covers on board to 260,000. These were later sold to collectors by the Postal Service.

The fourth Continuous Flow Electrophoresis System experiment was flown, using live human cells from a pancreas, kidney and pituitary gland. Also, six live rats were carried in an enclosure module being tested for the first time.

Other activities during the mission included a test of the RMS arm, using a special 7,460 lb. Development Flight Instrumentation Pallet. Numerous tests of the Orbiter's S-band and Ku-band antenna systems were performed with the Tracking and Data Relay Satellite. Thornton carried out biomedical experiments on himself and other members of the crew in a continuation of the Space Adaptation Syndrome studies by Thagard during the STS-7 mission.

STS-8 also conducted the first night landing in the program at 12:40 a.m. PDT, September 5, 1983 on Runway 22 at Edward AFB. The mission lasted 6 days, 1 hour, 8 minutes, 43 seconds. The Challenger had travelled 2.2 million miles and orbited the Earth 97 times. It was back at KSC in the record-breaking time of 4 days after its California landing.

STS-9

For the STS-9 mission the Columbia was once again back in orbit. The launch occurred at 11 a.m. EST, November 28, 1983 after a 2-month delay because of a nozzle problem with one of the SRB's. This necessitated moving the vehicle back to the Vehicle Assembly Building where the nozzle was replaced.

The 6-member crew included John W. Young, Commander, on his second Shuttle flight, Brewster H. Shaw, pilot, Owen Garriott and Robert A. Parker, mission specialists and Byron K. Lichtenberg and Ulf Merbold payload specialists, the first two non-astronauts to fly on the Shuttle. Merbold, a citizen of West Germany, was the first foreign citizen to participate in a Shuttle flight. Lichtenberg was a researcher at Massachusetts Institute of Technology.

The mission was devoted entirely to Spacelab 1, a joint NASA/European Space Agency (ESA). The program was designed to demonstrate the ability to conduct advanced scientific research in space with astronauts and payload specialists working in the Spacelab module coordinating their efforts with scientists at the Marshall Payload Operations Control Center (POCC) located at the Johnson Space Center. Funding for Spacelab 1 was provided by ESA.

The crew was divided into two teams, each working 12-hour shifts for the duration of the mission. Young, Parker and Merbold formed the Red Team, while Shaw, Garriott and Lichtenberg made up the Blue Team. Usually, the commander and the pilot team members were assigned to the flight deck, while the mission and payload specialists worked inside the Spacelab.

Seventy-two scientific experiments were carried out in the fields of atmospheric and plasma physics, astronomy, solar physics, material sciences, technology, life sciences and Earth observations. The effort went so well that the mission was extended an additional day to 10 days, making it the longest duration Shuttle flight to date.

The Spacelab 1 mission was highly successful, having proved the feasibility of the concept of carrying out complex experiments in space using non-NASA persons trained as payload specialists in collaboration with a POCC. Moreover, the Tracking and Data Relay Satellite, now fully operational, was able to relay vast amounts of data through its ground terminal to the POCC.

Columbia landed on Runway 17 at Edwards AFB, on December 8, 1983, at 3:47 p.m. PST, completing 166 orbits and travelling 4.3 million miles. The Columbia was ferried back to KSC on December 15, 1983.

STS 41-B

Following STS-9, the flight numbering system for Space Shuttle missions was changed. The next flight, instead of being designated STS-10, became STS 41-B. The new numbering system was designed to be more specific in that the first numeral stood for the fiscal year in which the launch was to take place, the "4" being 1984. The second numeral represented the launch site 1 for KSC and 2 for Vandenberg AFB, California. The letter represented the order of launch assignment, "B" was the second launch scheduled in that fiscal year. (Following the Challenger accident, NASA reestablished the original numerical numbering system. Thus the first flight following 51-L is STS-26.)

The mission was the fourth flight of the Challenger. Liftoff occurred at 8 a.m. EST, on February 3, 1984. Two communications satellites, one for Western Union (WESTAR) and the other for Indonesia (Palapa B-2), were deployed about 8 hours after launch. However, the Payload Assist Modules (PAM) for both satellites malfunctioned placing them into a lower than planned orbit. Both satellites were retrieved successfully the following November during STS 51-A, the 14th mission, by the Orbiter Discovery.

The STS 41-B crew included Commander Vance D. Brand, making his second Shuttle flight, pilot Robert L. Gibson, and mission specialists, Bruce McCandless II, Ronald E. McNair and Robert L. Stewart.

A highlight of the mission took place on the first day when astronauts McCandless and Stewart performed the first untethered space walk, operating the Manned Maneuvering Unit (MMU) for the first time. McCandless, the first human Earth-orbiting satellite ventured out 320 feet from the Orbiter, while Stewart tested the "work station" foot restraint at the end of the RMS. The seventh day of the mission, both astronauts performed an EVA to practice capture procedures for the Solar Maximum Mission satellite retrieval and repair operation planned for the next mission, STS 41-C.

Another important "first" for STS 41-B was the reflight of the West German-sponsored SPAS-1 pallet/satellite originally flown on STS-7. Unfortunately, it remained in the payload bay because of an electrical problem in the RMS. The mission also carried five GAS canisters, six live rats in the middeck area, a Cinema-360 camera and continuation of the Continuous Flow Electrophoresis System and the Monodisperse Latex Reactor experiments.

The 7-day, 23-hour, 15-minute, 55-second flight ended on February 11, at 7:15 a.m. EST at KSC's Shuttle Landing Facility, the first landing of a spacecraft at its launch site. The Challenger completed 127 orbits and travelled 2.8 million miles.

STS 41-C

The following April, The Challenger was once again flying in space, this time on the STS 41-C mission. Liftoff took place at 8:58 a.m. EDT, on April 6, 1984. It marked the first direct ascent trajectory for the Shuttle reaching its 288-mile-high orbit using the Orbiter Maneuvering System engines only once - to circularize its orbit.

The flight had two primary objectives. The first was to deploy the huge Long Duration Exposure Facility (LDEF), a passive, retrievable, 21,300 lb., 12 sided cylinder, 14 ft. in diameter and 30 ft. long carrying 57 experiments. The second objective was to capture, repair and re-deploy the malfunctioning Solar Maximum Mission Satellite, "Solar Max", launched in 1980.

The five-man crew included Robert L. Crippen, Commander, on his third Shuttle flight, pilot Francis R. Scobee and mission specialists, James D. van Hoften, Terry J. Hart and George D. Nelson.

On the second day of the flight, the LDEF was grappled by the RMS arm and successfully released into orbit. Its 57 experiments, mounted in 86 removable trays were contributed by 200 researchers from eight countries. Retrieval of the passive LDEF had been scheduled during 1985, but schedule delays and the Challenger accident have postponed the retrieval effort.

On the third day of the mission, Challenger's orbit was raised to about 300 miles, and it maneuvered to within 200 feet of Solar Max. Astronauts Nelson and van Hoften, wearing space suits, entered the payload bay. Nelson, using the MMU, flew out to the satellite and attempted to grasp it with a special capture tool called the Trunnion Pin Acquisition Device (TPAD). Three attempts to clamp the TPAD onto the satellite failed. It began tumbling when van Hoften attempted to grasp it with the RMS arm, and the effort was called off.

During the night, the Solar Max POCC, at Goddard Space Flight Center, Greenbelt, Md., was able to establish control over the satellite by sending commands ordering the magnetic torque bars to stabilize the tumbling action. This was successful and the Solar Max went into a slow, regular spin.

The next day, Nelson and van Hoften tried to capture it again. This time they succeeded on the first try. They placed Solar Max on a special cradle in the payload bay using the RMS. They then began the repair operation, replacing the satellite's attitude control mechanism and the main electronics system of the chronograph instrument. The ultimately successful repair effort took two separate space walks. Solar Max was deployed back into orbit the next day, thus concluding one of the most unique rescue and repair missions in the history of the space program.

After a 3-day checkout by the Goddard POCC, Solar Max resumed full operation.

Other STS 41-C mission activities included a student experiment located in a middeck locker to determine how honeybees make honeycomb cells in a microgravity environment. They did so successfully, just as on Earth.

The 6-day, 23-hour, 40-minute, 7-second mission ended on April 13, at 5:38 a.m. PST, with Challenger landing on Runway 17, at Edwards AFB. It had completed 108 orbits and travelled 2.87 million miles. Challenger was returned to KSC on April 18.

STS 41-D

The Orbiter Discovery was launched on its maiden flight - the 12th in the program - on August 30, 1984. It was the third Orbiter built and the lightest one thus far because of its lightweight thermal blanket material.

The mission was originally planned for June 25, 1984 but was postponed due to a variety of technical problems, including rollback to the VAB to replace a main engine, and a 6-minute, 50 second delay when a private aircraft flew into the restricted air space near the launch pad. The launch did not take place until 8:41 a.m. EDT, August 30, 1984. It was the fourth launch attempt for Discovery.

Because of the 2-month delay, the STS 41-F mission was cancelled (STS 41-E had already been cancelled) and its primary payloads were included on the STS 41-D flight. The combined cargo weighed over 47,000 lb., a Space Shuttle record up to that time.

The six-person flight crew consisted of Henry W. Hartsfield Jr., Commander, making his second Shuttle mission; pilot Michael L. Coats; three mission specialists: Judith A. Resnik, Richard M. Mullane and Steven A. Hawley; and a payload specialist, Charles D. Walker, an employee of the McDonnell Douglas Corp. Walker was the first commercially-sponsored payload specialist to fly aboard the Shuttle.

The primary cargo consisted of three communications satellites, SBS-D for Satellite Business Systems, Telstar 3-C for Telesat of Canada and SYNCOM IV-2, or Leasat-2, a Hughes-built satellite leased to the Navy. Leasat-2 was the first large communications satellite designed specifically to be deployed from the Space Shuttle. All three satellites were deployed successfully and became operational.

Another payload was the OAST-2 solar array, a device 13 feet wide and 102 feet high, which folded into a package 7 inches deep. The wind carried a number of different types of experimental solar cells and was extended to its full height several times. It was the largest structure ever extended from a manned spacecraft and demonstrated the feasibility of large lightweight solar arrays for future application to large facilities in space such as the Space Station.

The McDonnell Douglas-sponsored Continuous Flow Electrophoresis System (CFES) experiment, using living cells, was more elaborate than the one flown previously and payload specialist Walker operated it for more than 100 hours during the flight. A student experiment to

study crystal growth in microgravity was carried out, and the IMAX motion picture camera was operated during much of the flight.

The mission lasted 6 days, 56 minutes, with landing on Runway 17 at Edwards AFB, at 6:37 a.m. PDT, on Sept. 5. It travelled 2.21 million miles and made 97 orbits. It was transported back to KSC on Sept. 10.

STS 41-G

On Oct. 5, 1984, Challenger returned to flight with its launch at 7:03 a.m. EDT, marking the start of the STS 41-G mission. It was Challenger's sixth mission and the 13th liftoff in the Space Shuttle program.

On board were seven crew members - the largest flight crew ever to fly on a single spacecraft at that time. They included commander Robert L. Crippen, making his fourth Shuttle flight; pilot Jon A. McBride; three mission specialists - David C. Leestma, Sally K. Ride and Kathryn D. Sullivan - (the first time two female astronauts had flown together); and two payload specialists, Paul Scully-Power and Marc Garneau, the first Canadian citizen to serve as a Shuttle crew member.

Astronaut Sullivan became the first woman to walk in space when she and David C. Leestma performed a 3 hour EVA on Oct. 11 demonstrating the Orbital Refuelling System (ORS) and proving the feasibility of re-fueling satellites in orbit.

Nine hours after liftoff, the 5,087 lb., Earth Radiation Budget Satellite (ERBA) was deployed from the payload bay by the RMS arm, and its on-board thrusters boosted it into an orbit 350 miles above the Earth. ERBS was the first of three planned satellites designed to measure the amount of energy received from the sun and radiated into space. It also studied the seasonal movement of energy from the tropics to the polar regions.

Another major mission activity, operation of the Shuttle Imaging Radar-B (SIR-B) was conducted. SIR-B was part of the OSTA-3 experiment package in the payload bay, which also included the Large Format Camera (LFC) to photograph Earth, another camera called MAPS which measured air pollution, and a feature identification and location experiment called FILE which consisted of two TV cameras and two 70mm still cameras.

The SIR-B effort was an improved version of a similar device flown on the OSTA-1 package during STS-2. It had an eight-panel antenna array measuring 35 by 7 feet. It operated throughout the flight but problems were encountered with the Challenger's Ku-band antenna and therefore much of the data had to be recorded on board the Orbiter rather than transmitted to Earth in real-time as originally planned.

Payload Specialist Scully-Powers, an employee of the U.S. Naval Research Laboratory, performed a series of oceanography observations during the mission. Garneau conducted experiments sponsored by the Canadian government, called CANEX, which were related to medical, atmospheric, climatic, materials and robotic sciences. A number of GAS canisters covering a wide variety of materials testing and physics were also flown.

STS 41-G was an 8-day, 5-hour, 23-minute, 33-second mission which travelled 4.3 million miles and completed 132 orbits. It landed at the Shuttle Landing Facility at KSC - the second Shuttle landing there - on Oct. 13, at 12:26 p.m. EDT.

STS 51-A

Less than a month after the 41-G flight, the 14th Space Shuttle mission and the second for Discovery, STS 51-A was launched at 7:15 a.m. EST, No. 8, 1984. A launch attempt the day before was scrubbed at the T minus 20-minute built-in hold because of higher shear winds in the upper atmosphere.

The five-person flight crew consisted of Commander Frederick H. Hauck, on his second flight, pilot David M. Walker and three mission specialists - Anna L. Fisher, Dale A. Gardner and Joseph P. Allen. Both Gardner and Allen were making their second Shuttle flights.

This mission was unique in that it marked the first time the Shuttle had deployed two communications satellites and then went about retrieving from orbit two other communications satellites. B-2 and 6 had deployed during the STS 41-B mission earlier in the year and had been placed into improper orbits because their kick motors malfunctioned.

The two communications satellites successfully deployed were the Canadian Anik D2 - on the second day of the mission - and IV-1, also known as Leasat 1, on the third day.

The Orbiter then began a series of maneuvers to meet up with the first of the two satellites to be recovered, PALAPA B-2. (The orbits of both satellites had been lowered by ground commands from about 600 mile to 210 mile to facilitate recovery operations.) On day five, the Discovery rendezvoused with PALAPA. Mission specialists Allen and Gardner performed an EVA, capturing the satellite with a device known as a "Stinger", which was inserted into the apogee motor nozzle by Allen. The satellite's rotation was slowed to 1 RPM and Fisher, operating from a position on the end of the RMS, attempted unsuccessfully to grapple the satellite. However, all was not lost, because Allen was able manually to maneuver the satellite into its cradle with Gardner's help and aided by the RMS which was operated by Fisher. The successful improvised rescue effort took two hours.

The recovery of Westar 6 was not as difficult and took place a day later. This time Gardner, using the same muscle power technique Allen had used for the rescue, captured the satellite. With Allen's help, he placed it in a cradle in the cargo bay.

The STS 51-A mission also carried the Diffused Mixing of Organic Solutions (DMOS) experiment. It was the first of a series of comprehensive organic and polymer science experiments sponsored by the 3M Corp. This middeck experiment was successful and the proprietary results of the chemical mixes were turned over to 3M. One other experiment, the radiation monitoring experiment, was also performed.

This second Discovery mission ended at 7 a.m. EST, Nov. 16, with landing on Runway 33, at KSC, after a 7-day, 23-hour, 45-minute flight, which covered 3.3 million miles during 126 complete orbits. It was the third Shuttle landing at KSC and the fifth and last Shuttle mission of 1984.

STS 51-C

Discovery was to make its third flight in January 1985 to conduct the first mission totally dedicated to the Department of Defense. The classified payload was deployed successfully and boosted into its operating orbit by an Inertial Upper Stage (IUS) booster according to an Air Force announcement.

The launch occurred on Jan. 24, 1985, at 2:40 p.m. EST - the first of 10 Shuttle missions that year. It was originally scheduled for Jan. 23, but was delayed because of freezing weather conditions. The Challenger had been scheduled for this flight but Discovery was substituted when thermal tile problems were encountered with The Challenger.

The 51-C included Thomas K. Mattingly, Commander, Loren J. Shriver, pilot, James F. Buchli and Ellison S. Onizuka, mission specialists and Gary E. Payton, payload specialist.

The mission lasted 3 days, 1 hour, 33 minutes. Discovery touched down on Runway 15 at KSC on Jan. 27 at 4:23 p.m. EST.

STS 51-D

The 16th mission, officially designated STS 51-C, was launched at 8:59 a.m. EST, on April 12, 1985, just 55 seconds before the close of the launch window. It marked the fourth flight by Discovery.

Its seven-person crew included Karol J. Bobko, Commander; Donald E. Williams, pilot; three mission specialists - M. Rhea Seddon, S. David Griggs and Jeffrey A. Hoffman; and two payload specialists - Charles D. Walker of McDonnell Douglas and E.J. "Jake" Garn, a U.S. senator from Utah - the first elected official to fly on board the Space Shuttle. Garn was chairman of the Senate committee with oversight responsibilities for the NASA budget.

The primary objective of the flight was deployment of two communications satellites, Anik C-1, third in a series of Canadian satellites, and IV-3, also known as Leasat 3. Anik's deployment was carried out successfully a few hours after launch and its booster kick motor propelled it into its operational orbit. The deployment took place the next day. However, its booster stage failed to fire as programmed because the satellite's sequence start lever had failed to open. A possible "fix" was attempted by placing two so-called fly swatter devices on the end of the RMS to snag and tug on the failed lever. The mission was extended 2 days and astronauts Griggs and Hoffman performed an EVA to attach the fly swatter devices to the end of the RMS. Astronaut Seddon then manipulated the RMS, attempting to activate the lever into its operating position. The attempt failed. However, during the STS 51-I mission in August, the lever was repaired and the satellite reached its geosynchronous orbit and became operational.

Other activities during the flight included operation of a larger Continuous Flow Electrophoresis Experiment by payload specialist Charles Walker, two student experiments, one of which failed and an informal science study of how mechanical toys operate in microgravity.

Discovery landed on Runway 33 at KSC at 8:55 a.m. EST, April 19. Its right main gear tire blew out just at the Orbiter was rolling to a stop. The mission lasted 6 days, 23 hours, 55 minutes. Distance travelled was 2 million miles during 109 complete orbits.

STS 51-B

The second Spacelab mission, with the European-built Spacelab in its operational configuration, began on April 29, 1985, at 12:02 p.m. EDT, with the liftoff of Challenger on its seventh journey into space.

The seven-man crew was headed by Commander Robert F. Overmyer, Frederick D. Gregory, pilot, three mission specialists, Don L. Lind, Norman E. Thagard, William E. Thornton and two payload specialists, Lodewijk van den Berg of EG&G Energy Management Inc., and Taylor G. Wang of NASA's Jet Propulsion Laboratory.

The crew was divided into two teams each working 12-hour shifts, as would be the case on all Spacelab missions.

Spacelab 3 carried 15 primary experiments involving five basic scientific disciplines: materials and life sciences, fluid mechanics, atmospheric physics and astronomy. All but one of the experiments provided good scientific data. The mission was supported around the clock by the Marshall POCC.

In addition to the Spacelab effort, the flight carried two monkeys and 24 rodents in special cages for biomedical experimentation. Two GAS experiments were flown which, for the first time, required that payloads be deployed from the canisters. One of them, the Global Low Orbiting Message Relay Satellite, (GLOMAR) did not deploy and was returned to Earth. The other called NUSAT, for Northern Utah Satellite worked successfully.

Challenger landed at Edwards AFB, California, at 9:11 a.m. PDT, on May 6, 1985, after completing 110 orbits during its 7-day, 8-minute, 46-second mission.

STS 51-G

The 18th Space Shuttle mission was flown by Discovery following its liftoff at 7:33 a.m. EDT, on June 17, 1985. The cargo included three commercial communications satellites, a deployable/retrievable spacecraft call Spartan 1, six GAS experiment canisters, a tracking experiment for the Defense Department's Strategic Defense Initia-

tive, a materials processing furnace and a series of biomedical experiments sponsored by France.

The seven-member STS 51-G crew included Daniel Brandenstein, Commander, John Creighton, pilot, three mission specialists, Shannon Lucid, Steven Nagel and John Fabian and two payload specialists Patrick Baudry of France and Prince Sultan Salman Al-Saud of Saudi Arabia.

The three communications satellites were successfully deployed and their booster stages placed them into their planned operating orbits. They included Arabsat 1-B, owned by the Arab Satellite Communications Organization; Morelos 1, the first Mexican-operated communications satellite; and Telstar 3-D an American domestic communications satellite owned by American Telephone and Telegraph (AT&T).

The NASA-sponsored Spartan 1 carried a series of astronomy experiments and was the first in a planned series of short duration free flyers designed to extend the capabilities of sounding rocket type experiments. It weighed 2,223 pounds and was deployed and operated successfully, independent of the Orbiter, before being retrieved by the RMS later in the mission.

The materials furnace, the French biomedical experiments and the six Getaway Specials all operated successfully although one GAS experiment shut down early.

The Shuttle test of the Strategic Defense Initiative tracking experiment, called the High Precision Tracking Experiment (HPTE), failed during orbit 37 because the Orbiter was in the wrong attitude. However, the test was successfully completed during orbit 64.

The mission ended at 6:11 a.m. PDT, June 24, 1985 on Runway 23 at Edwards AFB, California. It travelled 2.9 million miles and made 111 complete orbits during its 7-day, 1-hour, 38-minute, 52-second flight.

STS 51-F

The Challenger was to return to orbit on July 12, 1985, with its launch marking the 19th Space Shuttle mission. A launch attempt on July 12 was stopped at the T-3 second mark - after main engine ignition had occurred - because of a failed coolant valve in the number two engine and all three engines were shut down. The launch was delayed until July 29, 1985 when liftoff occurred at 5 p.m. EDT, after a 1-hour, 37-minute delay because of problems with the Orbiter.

Although liftoff was normal, at 5 minutes, 45 seconds after launch, the number one main engine shutdown prematurely and an abort-to-orbit was declared. An orbit of 124 by 165 mile was achieved and later raised to an altitude of about 196 mile by a series of Orbital Maneuvering System burns.

Despite this initial problem, the third Spacelab effort, which was officially called Spacelab-2, was successful. (Spacelab-3 was flown out of sequence ahead of Spacelab-2 on STS 51-B as an operational mission, Spacelab-2 being the last Shuttle/Spacelab verification mission.)

The seven-man crew included Charles G. Fullerton, Commander, Roy D. Bridges, pilot, three mission specialists, F. Story Musgrave, Anthony W. England and Karl G. Henize and two payload specialists, Loren W. Acton of Lockheed Corp., and John-David Bartoe from the Naval Research Laboratory.

The Spacelab-2 payload consisted of an igloo and three pallets in the payload bay, containing scientific instruments dedicated to life sciences, plasma physics, astronomy, high-energy astrophysics, solar physics, atmospheric physics and technology research.

A major objective of the mission was to verify the performance of the Spacelab systems with the Orbiter as well as to measure the environment created by the vehicle in space.

The flight marked the first time ESA Instrument Pointing System (IPS) was tested in orbit. This unique experiment pointing instrument was designed with an accuracy of one arc second. Initially, some problems were experienced when it was commanded to track the Sun. A series of software fixes were made and the problem was corrected. The flight crew and the experts on the ground in the Marshall POCC worked closely together and much valuable scientific data was acquired.

Inside the pressurized Orbiter cabin four other experiments were carried out. These included two dealing with Vitamin D metabolites and bone demineralization which involved, among other things, taking physiological measurements of crew members. A third experiment dealt with determining the effect of microgravity on lignification in plants. Finally, the fourth cabin experiment, which was added late in planning for the mission, was concerned with protein crystal growth. All four experiments were declared successful.

The mission ended with Challenger landing at Edwards AFB, California, at 12:45 p.m. PDT, August 6, 1985 on orbit 127. Mission duration was 7 days, 22 hours, 45 minutes, 26 seconds.

STS 51-I

The Orbiter Discovery flew the 20th Space Shuttle mission with its launch at 6:58 a.m. EDT, August 27, 1985. Two earlier launch attempts, one on August 24, 1985 and another on August 25, 1985 were scrubbed, the first because of poor weather and the second because the backup Orbiter computer failed and had to be replaced. The successful August 27, 1985 launch took place just before an approaching storm front reached the launch pad area.

The five-man STS 51-I crew included Joe H. Engle, Commander, Richard O. Covey, Pilot and three mission specialists, James Van Hoften, John M. Lounge and William F. Fisher. Their primary mission was to deploy three commercial communications satellites and retrieve and repair IV-3 which was deployed during the STS 51-D mission in April 1985 and had malfunctioned. In addition, a middeck materials processing experiment was flown.

The three communications satellites included 1, a multi-purpose spacecraft owned by Australia, the ASC-1 owned and operated by the American Satellite Co. and IV-4 leased to the Department of Defense by its builder, the Hughes Co. Both 1 and ASC-1 were deployed on launch day, August 27. IV-4 was deployed two days later. All three achieved proper geosynchronous orbits and became operational.

On the fifth day of the mission, astronauts Fisher and van Hoften began repair efforts on the malfunctioning IV-3 following a successful rendezvous maneuver with Discovery. The effort was slowed because of a problem in the RMS elbow joint. In any event, after a second EVA by Fisher and van Hoften, the lever was repaired, permitting commands from the ground to activate the spacecraft's systems and eventually sending it into its proper geosynchronous orbit. The two EVAs took 11 hours and 27 minutes.

Discovery landed on Runway 23 at Edwards AFB at 6:16 a.m. PDT on September 3, 1985. The flight took 7 days, 2 hours, 18 minutes, 42 seconds, completing 111 orbits of the Earth.

STS 51-J

The first flight by the Orbiter Atlantis occurred October 3, 1985, its successful launch at 11:15 a.m. EDT. STS 51-J was the second Space Shuttle mission totally dedicated to the Department of Defense. The cargo, orbital parameters and other details of the flight were classified. Its five-man crew included Karol L. Bobko, Commander, Ronald J. Grabe, pilot, two mission specialists, Robert L. Steward and David Hilmers and one payload specialist, William A. Pailes.

Atlantis performed well on its maiden flight and the mission was declared successful. Landing took place at Edwards AFB at 10:10 a.m. PDT, October 7, 1985. The flight duration was 4 days, 1 hour, 45 minutes.

STS 61-A

The STS 61-A mission, the first dedicated West German Spacelab, saw the Challenger liftoff at 12:00 noon EST, October 30, 1985. The 22nd launch in the Shuttle program, the countdown and the ascent to orbit went flawlessly.

The eight-person crew was the largest ever to fly a sizeable spacecraft at one time. The crew included Henry W. Hartsfield, Commander, Steven R. Nagel, pilot, Bonnie J. Dunbar, James F. Buchli and Guion S. Bluford, mission specialists and Ernst Messerschmid and Reinhard Furrer of West Germany and Wubbo Ockels from the ESA, payload specialists.

The primary objective of the mission officially designated Spacelab D-1, was to conduct a series of experiments relating to materials processing. This fourth Spacelab mission was the first Shuttle flight to be largely financed and conducted by another nation. NASA was responsible for operation of the Shuttle and for safety and control functions, controlling the flight from the Mission Control Center in Houston. West Germany was responsible for the Spacelab scientific research. The flight crew, on 12-hour shifts, worked closely with ground controllers at the German Space Operations Center at Oberpfaffenhofen.

Two other STS 61-A mission objectives included deployment of the Global Low Orbiting Message Relay (GLOMR) satellite, which was to be deployed from a Getaway Special canister and operation of five materials processing experiments mounted in the cargo bay on a structure called the German Unique Support Structure. The GLOMR deployment and the materials processing experiments were successful.

The Spacelab D-1 scientific research effort consisted of 75 separate experiments most of which were repeated several times during the mission. Since the effort was directed primarily at materials processing science, the primary experiments were related to fluid physics, solidification experiments and biological and medical investigations. It was the most comprehensive investigation of materials processing in space and associated human activities ever undertaken.

The Challenger landed on Runway 17 at Edwards AFB AT 9:45 a.m.

PST, November 6, 1985. The mission duration was 7 days, 44 minutes, 51 seconds.

STS 61-B

Atlantis made its second voyage into space on November 26, 1985, with its launch at 7:29 p.m. EST, the second night launch in the program. Liftoff occurred on schedule. The countdown and ascent to orbit, as on the previous flight, went flawlessly.

The seven-person crew was comprised of Brewster H. Shaw Jr., Commander, Bryan D. O'Connor, pilot, Mary L. Cleave, Sherwood C. Spring and Jerry L. Ross, mission specialists and Rodolfo Neri Vela from Mexico and Charles Walker of McDonnell Douglas on his second Shuttle flight, payload specialists

The primary objective of the mission was to deploy three communications satellites, the Mexican-owned Morelos-B, 2 for Australia and Ku-2 owned and operated by RCA American Communications (RCA Americom). All three satellites were deployed as planned and subsequently achieved their geosynchronous operating orbits.

Two experiments designed to test the feasibility of assembling erectable structures in space were carried out. These were the Experimental Assembly of Structures in Extravehicular Activity (EASE), a geometric structure composed of beams and nodes shaped like an inverted pyramid and the Assembly Concept for Construction of Erectable Space Structures (ACCESS), which was a tall tower consisting of numerous small struts and nodes. The lightweight metal structures were assembled by astronauts Ross and Spring during two EVAs which lasted 5 hours, 32 minutes and 6 hours, 38 minutes. These activities were captured on film by the large-screen motion picture camera, IMAX.

During the flight payload specialist Walker again operated the Continuous Flow Electrophoresis System experiment which was designed to produce commercial pharmaceutical products in microgravity. Payload specialist Rudolfo Neri Vela, of Mexico, carried out a number of human physiology experiments. Another experiment, the 3M's Diffuse Mixing of Organic Solutions (DMOS) was successfully operated, growing large, pure single crystals in microgravity. A Canadian-sponsored GAS canister to fabricate mirrors in space was also tested.

STS 61-B was a 6-day, 21-hour, 4-minute, 49-second mission. Landing occurred at 1:33 p.m. PST, December 3, 1985 on Runway 22 at Edwards AFB.

STS 61-C

Mission 24 in the Space Shuttle program saw the Orbiter Columbia return to flight for the first time since the STS-9 mission in November 1983, after undergoing major modifications by Rockwell International in California.

The launch originally was scheduled for December 18, 1985 but the closeout of an aft Orbiter compartment was delayed and the mission was rescheduled for the next day on December 19, 1985. The count-down was stopped at T-14 seconds because of an out-of-tolerance turbine reading on the right SRB's hydraulic system.

Another launch attempt on January 6, 1986 was terminated at T-31 seconds because a problem in a valve in the liquid oxygen system could not be fixed before the end of the launch window. Other launch attempts were made on January 7, 1986 that were scrubbed because of bad weather at contingency landing sites, Dakar, Senegal and Moron, Spain. The launch on January 9, 1986 was delayed because of a problem with a main engine prevalve and the launch on January 10, 1986 because of heavy rain in the launch area.

The launch finally took place at 6:55 a.m. EST, on January 12, 1986 without complications.

The flight crew included Robert L. Gibson, Commander, Charles F. Bolden, pilot, Franklin Chang-Diaz, Steven A. Hawley and George D. Nelson mission specialists and Robert Cenker RCA Astro-Electronics and U.S. Congressman Bill Nelson, payload specialists.

The primary objective of the mission was to deploy the Ku-1 communications satellite, the second in a planned series of geosynchronous satellites owned and operated by RCA Americom. The deployment was successful and the satellite eventually became operational. The flight also carried a large number of small experiments, including 13 GAS canisters devoted to investigations involving the effect of microgravity on materials processing, seed germination, chemical reactions, egg hatching, astronomy and atmospheric physics. Other cargo included a Materials Science Laboratory-2 structure for experiments involving liquid bubble suspension by sound waves, melting and resolidification of metallic samples and containerless melting and solidification of electrically conductive specimens. Another small experiment carrier located in the payload bay was the Hitch-hiker G-1 (HHG-1) with three experiments to 1) study film particles in the Orbiter environment, 2) test a new heat transfer system and 3) determine the effects of contamination and atomic oxygen on ultraviolet optics materials. There were also four in-cabin experiments, three of them part of the Shuttle Student Involvement Program.

Finally, an experiment called the Comet Halley Active Monitoring Program (CHAMP), consisting of a 35mm camera to photograph the comet Halley through the aft flight deck overhead window was not successful because of battery problems.

Not only was the STS 61-C mission difficult to get off the ground, it proved to be difficult returning back to Earth. A landing attempt on January 16, 1986 was cancelled because of unfavorable weather at Edwards AFB. Continued bad weather forced another wave-off the following day, January 17, 1986. The flight was extended one more day to provide for a landing opportunity at KSC on January 18, 1986, in order to avoid time lost in an Edwards AFB landing and turn-around. However, bad weather at the KSC landing site resulted in still another wave-off.

Columbia finally landed at Edwards AFB AT 5:59 a.m. PST, on January 18, 1986. Mission elapsed time was 6 days, 2 hours, 3 minutes, 51 seconds.

STS 51-L

The 25th mission in the Space Shuttle program, flown by the Challenger, ended tragically with the loss of its seven crew members and destruction of the vehicle when it exploded shortly after launch.

The launch was the first from Pad B at KSC's Launch Complex 39 and occurred at 11:38 a.m. EST, on January 28, 1986. The flight had been scheduled six times earlier but was delayed because of technical problems and bad weather.

One minute, 13 seconds after liftoff, the vehicle exploded and was destroyed.

All seven members of the crew were killed. They were Francis R. Scobee, Commander, Michael J. Smith, pilot, Judith A. Resnik, Ellison Onizuka and Ronald E. McNair, mission specialists, Gregory Jarvis of Hughes Aircraft, payload specialist and S. Christa McAuliffe, a New Hampshire teacher. She was the first Space Shuttle passenger/observer to participate in the NASA Teacher in Space Program and had planned to teach lessons during live television transmissions.

The primary cargo was the second Tracking and Data Relay Satellite (TDRS). Also on board was another Spartan free-flying module which was to observe Halley's Comet.

NASA - Real Estate

LAUNCH SITES

CAPE CANAVERAL

"The future is not free: the story of all human progress is one of struggle against all odds. We learned again that this America which Abraham Lincoln called the last, best hope of man on Earth, was built on heroism and noble sacrifice. It was built by men and women like our seven star voyagers, who answered a call beyond duty, who gave more than was expected or required and who gave it little thought of worldly reward."

President Ronald Reagan January 31, 1986

The world famous space launch site has been home to everything from the Apollo launches to the less publicized military missions and will be the launch site for the Space Station due for launch in the 1990's. Its most imposing feature is the Vehicle Assembly Building or VAB, originally designed to house the Saturn 5 moon rockets. The hanger is so huge that the doors must remain closed to stop clouds from forming inside! In contrast to Vandenberg, Canaveral assembles their craft away from the launch site to minimize atmospheric damage, a process which allows them 24 Shuttle launches a year. The launches themselves are handled from Mission Control in Houston, although this may revert to Canaveral once Texas takes over responsibility for the Space Station in the 1990's.

VANDENBURG AIR FORCE BASE

The second launch site after Cape Canaveral, Vandenberg saw its first orbital launch in 1959 when an early spy satellite became the first man-made object to reach a polar path. Since then it has seen 478 spaceflights, although the Shuttle is its first manned project. Vandenberg was to be Discovery's dedicated site as early as 1985 but this was unfortunately set back by the tragic loss of Challenger. Although smaller than Cape Canaveral, Vandenberg is now close to being a fully independent launch site and is actually preferable for civilian reconnaissance satellites that require a low-inclination orbit.

LANDING SITES

EDWARDS AIR FORCE BASE

This California base saw the very beginning of the re-usable space-craft program when the X-15, the first vehicle to confuse the line between air and space craft, was released from a B-52 in 1959. At the outset, the enormous dry lake bed was the main landing site for the Shuttle program until the Kennedy Space Center began to be used in 1984. It has seen every piece of drama, from the first test flights of the Flash Gordon-like lifting bodies of the fifties to the first nerve-wracking landing of the STS-1 Colombia less than twelve years later.

ZARAGOZA, SPAIN

The landing strip in Zaragoza, Spain is one of two main emergency strips used as back up by Houston in case of adverse weather conditions or orbital failure. Normally housing the 406th Tactical Fighting Wing of the US Air Force, this long strip of Northern Spain is the usual destination of a newly launched Shuttle in the event of TAL abort, i.e., with sufficient speed to pass Florida. Thankfully, it's rarely even thought to be needed, and can carry on with its usual task of training USAF pilots. Rota Naval Air Base in Southern Spain is also an emergency option. If either were to be used, they'd break the record for a Trans-Atlantic flight, ETA around 10 minutes!

WHITE SANDS, NEW MEXICO

Normally a missile testing strip in the deserts of Southern America, White Sands is an alternative to Edwards AFB as an AOA landing strip, that is, when enough speed has been built up to take the Shuttle once around the Earth and back again.

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